EAST AFRICAN COMMON SERVICES ORGANIZATION

EAST AFRICAN AGRICULTURE
AND
FORESTRY RESEARCH ORGANIZATION

RECORD OF RESEARCH

for the period

1st January to 31st December, 1961

ANNUAL REPORT, 1961

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RECORD OF RESEARCH

For the period 1st January to 31st December, 1961

ANNUAL REPORT, 1961

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DIRECTORATE

E. W. Russell, C.M.G., M.A., PH.D., F.INST.P.	*Director.*
W. J. A. Payne, M.A., PH.D., DIP.AGRIC.SC.	*Deputy Director.*

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W. J. A. Payne, M.A., PH.D., DIP.AGRIC.SC.	*Officer-in-Charge*
H. G. Livingston, B.SC., PH.D., DIP. DIARY HUSBANDRY	*Animal Nutritionist*
H. P. Ledger, N.D.D.	*Meat Research*
A. F. Dent, DIP. AGRIC., DIP. DAIRYING	*Farm Manager.*
M. Njoroge, M.SC.	*Scientific Assistant*
I. Patchett	*Agricultural Assistant*
Watson Njenga	*Laboratory Assistant*
Nelson Mwangi	*Recorder*
James G. Rimomo	*Recorder*
Jonathan Session	*Recorder*
Henya A. Kinuthia	*Recorder*
Mayda Kapitapa	*Farm Overseer*
Duncan Mbugua	*Clerk*

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Paul Mungai	*Laboratory Assistant*

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A. J. Searle	*Scientific Assistant*
P. K. Patel, B.SC.	*Scientific Assistant*
Leonard Nganga	*Laboratory Assistant*
Chege Mugane	*Laboratory Assistant*

Ecology

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Forestry

A. L. Griffith, O.B.E., M.A., D.SC.	*Silviculturist-in-Charge*
P. Howland	*Forester*
Evanson Ndungu	*Laboratory Assistant*
Amos Wanene	*Computor*
Ernest Warari Muregi	*Forest Ranger*

Forest Entomology

W. Wilkinson, B.SC., M.I.BIOL.	*Forest Entomologist*
T. Jones, B.SC., A.R.C.S., F.I.W.SC.	*Forest Entomologist*
Martin Karanja	*Laboratory Assistant*
Josephat Kamau	*Laboratory Assistant*

Horticulture and Nursery

W. B. May, F.R.H.S.	*Horticulturist*
Angel Gathara	*Nursery Foreman*

Nematology

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Mrs. M. A. Ledger, N.D.D.	*Scientific Assistant*
Livingstone Kariuki	*Laboratory Assistant*
Njenga Kinyanjui	*Laboratory Assistant*

PHYSICS

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O. Kerfoot, M.A., B.SC.	*Silviculturist*
M. Dagg, B.SC., PH.D.	*Soil Physicist*
P.H. Hosegood	*Scientific Assistant*
J. A. Forsgate	*Scientific Assistant*
Peter Ngugi Nganga	*Computer*
Edward Stephen Waweru	*Computer*
Jamen Adenya	*Computer*
Herman Lomosi	*Laboratory Assistant*
Samuel Mwanzia	*Laboratory Assistant*
Wallace Gichuru	*Laboratory Assistant*
Jacob Mudianga	*Laboratory Assistant*
Eluid Ndungu Kago	*Laboratory Assistant*
Francis Ngugi Charles	*Observer*
Sabino Obol	*Observer*
Joshua Njoroge Kuria	*Observer*
Daniel Levi	*Observer*
David Njuguna	*Observer*

SORGHUM BREEDING

H. Doggett, M.A., A.I.C.T.A.	*Plant Breeder-in-Charge*
D. Jowett, B.SC., PH.D.	*Plant Breeder*
John Muganza	*Recorder*
Henry Ojulong	*Recorder*
Samuel Echako	*Recorder*
Samuel Odele	*Recorder*
Winston Ogola	*Recorder*
Raphael Okello	*Recorder*
Israel Apedel	*Recorder*
Blasius K. Masaaba	*Recorder*
John Oposia	*Recorder*

PLANT PATHOLOGY

H. H. Storey, C.M.G., M.A., PH.D., F.R.S.	*Plant Pathologist*
Miss F. M. L. Sheffield, D.SC.	*Plant Pathologist*
Mrs. A. K. Howland, B.SC.	*Scientific Assistant*
H. Y. Kulkarni, M.SC.	*Scientific Assistant*
Ferdinand Wamagata	*Laboratory Assistant*
Geoffrey Kuria	*Laboratory Assistant*
James Kuria Njoroge	*Laboratory Assistant*

PLANT PHYSIOLOGY

J. Glover, M.SC.	*Plant Physiologist*
Amos Chege Kagunyi	*Laboratory Assistant*

SOIL SURVEY

R. M. Scott, B.SC.	*Soil Surveyor*
Stephen Kamau Nahashon	*Laboratory Assistant*

SYSTEMATIC BOTANY

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G. L. Lucas, B.SC., F.L.S.	*Botanist*
Miss D. M. Napper, B.SC.	*Scientific Assistant*
George Williams	*Laboratory Assistant*
Edoward P. K. Kaya	*Laboratory Assistant*
Samwell Paul	*Laboratory Assistant*
Petro C. Owite	*Clerk*

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY

Mrs. L. D. Verdcourt, A.L.A.	*Librarian*
Miss J. P. H. Storey	*Assistant to Librarian*
Daniel Lazarus	*Assistant Librarian*
Joseph Okakah	*Senior Book-binder*

THE EAST AFRICAN AGRICULTURAL AND FORESTRY JOURNAL

J. Glover, M.SC.	*Editor*
H. F. Birch, B.SC., PH.D.	*Acting Editor*
Mrs. M. Drummond	*Assistant Editor*

THE EAST AFRICAN PLANT QUARANTINE STATION

Miss F. M. L. Sheffield, D.SC.	*Pathologist-in-Charge*
P. J. Dickinson, DIP. HORT.	*Scientific Assistant*
David N. Ngusa	*Laboratory Assistant*

ADMINISTRATION

ADMINISTRATION AND ACCOUNTS

Lt. Col. G. G. Robson, P.S.C.	*Administrative Secretary*
(G. H. Simpson, F.A.C.S.)	*Accountant, posted from Accountant General's Office*
Mrs. M. A. E. Bwye	*Personal Secretary to Director*
Mrs. M. M. May	*Personal Secretary*
Mrs. G. L. Dickinson	*Personal Secretary*
Mrs. J. U. Patchett	*Personal Secretary*
Mrs. W. Griffith	*Secretary/Stenographer*
(S. I. Mascarhenas)	*Accounting Assistant, posted from Accountant General's Office*
(G. J. Oraro)	*Accounts Clerk, posted from Accountant General's Office*
Matthew N. Waweru	*Administrative Clerk*
William K. Peter	*Clerk*
Edward Munyua	*Clerk/Telephonist*

MAINTENANCE, WORKSHOPS AND STORES

J. B. Drummond, M.I.C.W.A.	*Senior Maintenance Superintendent*
L. Boundford	*Maintance Superintendent.*
L. R. F. D'Souza	*Storekeeper*
Sher Mohammed	*Senior Foreman*
Noor Mohamed	*Foreman Artisan*
Tufail Mohammed	*Foreman Artisan*
Soma Puna	*Senior Artisan*
Arthur Robert	*Artisan*
Ngaruiya Waweru	*Artisan*
Peter Kimani Mukuria	*Artisan*
Kamau Kangethi	*Artisan*
Muigai Njuguna	*Artisan*
Kamiti Gichuhi	*Artisan*
Mohamed Hassan	*Artisan*
Mwaura Ngabu	*Artisan*
Benson Gaithu	*Artisan*
Benson Makumi	*Artisan*
John Kihanya	*Artisan*
Kiarie Gachohi	*Artisan*
Kiragu Ndungu	*Artisan*
Njuguna Kibe	*Artisan*
Hezron Kagone	*Artisan*
Geoffrey Mburu	*Stores Clerk*
Mwaura Mukuria	*Stores Clerk*
John Ndungu	*Clerk*
Saduma Otiende	*Clerk*
Joseph N. Njoroge	*Clerk*
Jackton Owake	*Overseer*
Kitonga Kiarie	*Driver*
Kinyanjui Macharia	*Driver*
Muchane Wamuti	*Driver*
Wamagata Karanja	*Driver*
Njuguna Gicharu	*Driver*

DEPARTURES DURING 1961

H. C. Pereira, D.SC.	*Deputy Director, on resignation*
K. R. Southon, DIP. AGRIC. (EGERTON)	*Scientific Assistant, on resignation*
Mrs. A. E. Bazin	*Scientific Assistant, on resignation*
C. A. Spinage	*Scientific Assistant, on resignation*
M. A. C. Pratt	*Scientific Assistant, on resignation*
R. M. Polhill, B.A.	*Scientific Assistant, on resignation*

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PREFACE

The East African Agriculture and Forestry Research Organization (E.A.A.F.R.O.) is an interterritorial research organization administered by and forming part of the East Africa High Commission. It was set up in 1948 and absorbed the earlier East African Agricultural Research Institute at Amani, Tanganyika, which was started in 1927. E.A.A.F.R.O. is financed jointly by the three East African Territories of Kenya, Tanganyika and Uganda, by the Protectorate of Zanzibar, and by the United Kingdom Government through Colonial Development and Welfare Funds. Its headquarters and central laboratories, experimental farm and forest plantations are in Muguga Forest near Nairobi on a site generously given by the Government of Kenya.

E.A.A.F.R.O. works very closely with the corresponding organization for veterinary research, the East African Veterinary Research Organization (E.A.V.R.O.). The two organizations have a common headquarters at Muguga, and the two sets of laboratories and farms are on adjoining estates each excised from the Muguga Forest. They are jointly responsible for the Library, which is the largest and most complete library for agriculture and the agricultural and ancillary sciences in East Africa. In addition, research work on animal industry is shared out between them. Work on the more practical aspects of animal management and nutrition is the responsibility of the E.A.A.F.R.O. Animal Husbandry Division, whilst work on animal physiology, biochemistry and genetics is that of the E.A.V.R.O. Animal Production Division. The Muguga South Farm, which is managed by the Director, E.A.A.F.R.O., is used by both these Divisions.

The general research policy for E.A.A.F.R.O. is decided by the East African Agricultural and Fisheries Research Council, a Council whose members are nominated by the Territorial Governments, the High Commission and the Colonial Office, and this Council is also responsible for the general running of this Organization.

The principal functions of E.A.A.F.R.O. are to undertake research work that is either longer-termed than is easily undertaken by the Territorial Departments of Agriculture and Forestry, or is common to all or several of the Territories, or which requires highly specialized equipment or research officers, which can only be justified in a central East African laboratory. Examples of each of these types of work will be found in the body of this Report.

E.A.A.F.R.O., however, is only concerned with problems of local interest when specially invited by a Territorial Department. Its function is therefore to supplement and supply the background to the work of the territorial research workers.

The planning of the detailed research policy of E.A.A.F.R.O. must obviously be done in very close co-operation with the Territorial Departments, and this is ensured through three Research Co-ordinating Committees. These Committees, and others for other sciences, are under the Chairmanship of the Chief Administrative Secretary of the High Commission, and the Director E.A.A.F.R.O. is a member of each. These Committees are for Agriculture, on which are the four Territorial Directors of Agriculture; for Animal Industry, on which are the Directors of Agriculture, the Directors of Veterinary Services and the Director E.A.V.R.O.; and for Forestry on which are the Chief Conservators of Forests. These Committees, in conjunction with the Research Council, keep under review all the research work in progress and decide on general priorities for research, particularly the long-term or more specialized research that is the direct concern of E.A.A.F.R.O.

E.A.A.F.R.O. is also directly concerned with a further set of Committees, the Specialist Committees, which are composed of the actual specialist research workers in East Africa in each of the disciplines represented. These Committees are therefore competent to discuss the technical problems with which the research workers are faced in carrying out their work, and to make detailed proposals for new work or for an extension of current work.

It was decided at the 3rd Meeting of the Research Council held on 3rd February, 1955, that the Annual Reports of E.A.A.F.R.O. should be published in two parts; one part, which is contained in the Annual Report of the Research Council itself, is intended to tell the non-scientist of the work and achievements of E.A.A.F.R.O. in the year under review; the other part, which is this Report, is written more for the information of research workers, particularly in other parts of the world.

This description of the way E.A.A.F.R.O. is administered, and the methods used to ensure that its programme of work fits into the desired pattern of interterritorial research is substantially correct for the year 1961. But on December 9th, the day Tanganyika became an independent country, the High Commission ceased to exist, and certain of its functions, including the administration of interterritorial research, were taken over by the East African Common Services Organization. As a consequence, the constitution and terms of reference of the East African Agricultural and

Fisheries Research Council and its sub-committees automatically come up for review. The East African Governments set up a Commission under the Chairmanship of Professor A. C. Frazer, M.D., D.Sc., F.R.C.P., to advise them on the best structure for the management, direction and financing of research on an East African basis. The Commission submitted its Report on the 20th October, and it is still under consideration by the Governments concerned at the end of the year.

INTRODUCTION

Staff Changes

No new Research Officers were recruited this year. The only Research Officer who left during the year was Dr. H. C. Pereira, the Deputy Director and Head of the Physics Division, who left at the end of May to take up the new post of Director of Research of the Agricultural Research Council of Rhodesia and Nyasaland. He has been succeeded as Deputy Director by Dr. W. J. A. Payne, the Head of the Animal Husbandry Division, and as Head of the Physics Division by Dr. J. S. G. McCulloch, who has been a member of that Division for five years.

Five members of the Scientific Assistant or Field Assistant staff resigned, K. R. Southon and Mrs. A. E. Bazin of the Animal Husbandry Division, C. A. Spinage of the Spectrochemical Unit, M. A. C. Pratt of the Physics Division and R. M. Polhill of the Herbarium, who however was a supernumerary. Four new members were appointed—I. Patchett and M. Njoroge to the Animal Husbandry Division, P. K. Patel to the Spectrochemical Unit and H. Y. Kulkarni to the Plant Pathology Division.

Two members of the Laboratory Assistant staff have been promoted to the D (Training) Scale this year, P. N. Nganga and E. W. Waweru, both of whom are computers and are being trained as Statistical Assistants. The Director of the East African Statistical Department has very kindly allowed these two officers to attend the training courses he has arranged for his own Department. It is hoped that suitable courses for other members of our Laboratory Assistant and Clerical Grades can be arranged in the near future so that some more officers can be promoted into the Training Grade.

Honours

Mr. Mayda Kapitapa, the Farm Overseer, was awarded a Queen's Certificate and Badge of Honour in recognition of his long and loyal services to this Organization and its predecessor, the East African Agricultural Research Institute.

Grants from Outside Foundations

It is again gratifying to report that we continue to receive help from Foundations. This year the Munitalp Foundation provided the money for a Mobile Meteorological Laboratory for the joint use of the Physics Division, E.A.A.F.R.O., and the East African

Meteorological Department. All the equipment needed for it has been ordered, and it is hoped that it will be ready for use early in 1962. The Foundation has also generously given a Research Fellowship for an Agricultural Meteorologist to work in this Laboratory, and it is gratifying to note that several very suitable meteorologists applied for the post. It is hoped that the applicant appointed will arrive at about the same time as the Laboratory is completed.

We have had only one visiting scientist working for any length of time this year. He was Dr. M. D. Gwynne, a Nuffield Research Fellow from the Botany Department of Oxford University, who arrived last year and completed his 12 months' work in our Plant Physiology Division in September. The Foundation very generously supplied all the special equipment needed for his work.

Visiting Scientists

Five research workers, four of whom were from other parts of Africa, paid extended visits to the Physics Division to study and familiarize themselves with some of the techniques we have developed.

Work on Outside Committees and Conferences

The Director was Chairman of the First Inter-African Hydrology Conference organized by the Commission for Technical Co-operation in Africa South of the Sahara (C.C.T.A.) held in Nairobi from 16th to 25th January. This was attended by all members of the Physics Division, who contributed very extensively to the discussions, and staged a very fine exhibition of their hydrological work. He was also Chairman of a Symposium on the Organization of Agricultural Research in Africa, which was organized by C.C.T.A. and held at Muguga from 11th to 15th December. He was a member of a Mission appointed by the Governor of Mauritius to report on the future of the tea industry in that island. He attended a Conference of Directors and Senior Officers of Overseas Departments of Agricultural Institutions held at Wye in September. He organized and was Chairman of a Conference on problems of managing land in areas containing both cattle and game, which was held at Lake Manyara in February. He was Chairman of the Conference of the Senior Soil Chemists held at Muguga in May; of a Conference on some problems of managing semi-arid lands, also held at Muguga in May, at which Dr. Pereira and his colleagues were asked to summarize some of the more important applications of their work in this field; and of the Pasture Research Committee which was held at Makerere in October.

The Director is a member of the East African Agricultural, Animal Industry, and Forestry Research Co-ordinating Committees, the Kenya Agricultural and Veterinary Research Advisory Committee, the Kenya Pasture Research Advisory Committee, the Research Committee of the Kenya Coffee Board and of the Kenya and Tanganyika Sisal Research Committees, the Kenya National Dairy Committee, and of the Research Advisory Committee of the Ngorongoro Conservation Authority. He is a member of the Governing Body of the Tea Research Institute of East Africa and Chairman of its Research Committee; a member of the Namulonge Advisory Board of the Empire Cotton Growing Corporation; a member of the Scientific Council for Africa South of the Sahara (C.S.A.), and attended its 12th Meeting at Pointe Noire in August; and is a member of the Agricultural Research Council of Rhodesia and Nyasaland.

Dr. H. H. Storey is a member of the East African Medical Research Council and of the East African Industrial Research Board, and a Trustee of the Coryndon Museum. He is Chairman of the Specialist Committee on Agricultural Botany, which met at Makerere in September, and Chairman of the East African Standing Technical Committee on Plant Import and Export, of which Dr. F. M. L. Sheffield is also a member, and Mr. P. J. Dickinson of the East African Plant Quarantine Station is Secretary.

Dr. Sheffield attended the Sixth Annual Meeting of the Inter-African Phytosanitary Commission held at Ibadan, and was leader of the United Kingdom delegation as well as being the East African representative.

Dr. W. J. A. Payne attended the Eighth International Congress of Animal Production held in June at Hamburg, at which he presented several papers on the Division's work. He has been invited by F.A.O. to serve as a member of a World Panel of Experts on Animal Nutrition Problems, and attended a meeting of the F.A.O. Animal Nutrition Panel in October in Washington, at which he also attended a meeting of representatives of the World Animal Production Associations. He is a member of the Kenya Pasture Research Advisory Committee and, with Dr. H. G. Livingston, a member of the Research Advisory Committee of the Kenya Pig Industry Board.

Dr. A. L. Griffith attended the 13th Congress of the International Union of Forest Research Organizations in Vienna in September and was appointed a member of their International Committee. He is a member of the East African Timber Advisory Board, Chairman of the Specialist Committee on Forestry Research

and a member of the Planning Committee for the forthcoming Commonwealth Forestry Conference. Mr. W. Wilkinson attended a Symposium on Insect Polymorphism in London, and also the Fourth International Congress of the International Union for the Study of Social Insects in Pavia, at which he presented some of the work of the Forest Entomology Division. Both he and Mr. T. Jones attended the East African Timber Advisory Board meeting, and Mr. Jones attended the meeting of the Specialist Entomological and Insecticidal Committee at Mwanza.

Dr. J. S. G. McCulloch attended a Radiation Symposium convened by W.M.O. in Vienna. Mr. H. Doggett was invited to attend and address the Seed Improvement Seminar sponsored by the International Co-operation Administration in Nairobi in June. Dr. H. F. Birch served on the Kenya Wheat Baking Quality Committee.

PHYSICS

Catchment Area Research

H. C. Pereira, J. S. G. McCulloch, M. Dagg, O. Kerfoot, P. H. Hosegood, J. Forsgate, M. A. C. Pratt, assisted by Edward Waweru, Peter Ngugi, Herman Lomosi, Samuel Kinyali,, Francis Ngugi, Eluid Kago, David Njuguna, Joshua Kuria, Wallace Gichuru, Sabino Obol and Daniel Levi

In previous annual reports an ambitious series of interdepartmental catchment area studies in all three East African territories was discussed; the results of the period 1956-1961 have now been prepared for publication as a Special Issue of the East African Agricultural and Forestry Journal. Preparation of numerous papers and reports for this issue has occupied the entire Physics and Statistics Division staff during 1961. It should, however, be stressed that the Special Issue includes reports from all the territorial specialist officers who have collaborated in the experiments, and a total of 32 papers is being presented. The continued interest and enthusiasm in these research projects, which has been shown by territorial officers throughout the year has proved of invaluable assistance to the central team in collecting data and in maintaining apparatus; catchment experiments as far apart as Mbeya and Moroto would be impracticable without real backing from field officers on the spot.

The Royal Show in September 1961 proved an opportunity to present this co-operative project to the general public. In collaboration with the Kenya Ministries of Forests and Works, a full display was mounted in the High Commission corner pavilion; apparatus demonstrated included a streamflow recorder operating in the ornamental pond.

The publication of the Special Issue marks the end of the initial phase of the catchment studies. During this period, techniques of measurement and of assessment have been developed, and each member of the Physics Division team contributed his own specialized knowledge and skill. Now nature must contribute, in that trees planted must mature, tea gardens must come into bearing and grazing regeneration must be permitted. Therefore a full-time post of Catchment Executive Officer has been created, so that the responsibility for the routine running of the experiments, calculation of the data and evaluation of the water balance is centralized

on one officer. The other officers of the division are of course still called upon to investigate anything of a research, rather than a routine, nature.

Techniques of Catchment Area Analysis

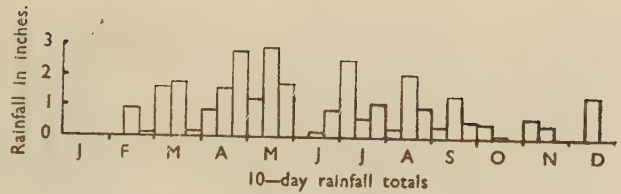
These were mentioned briefly in last year's Record of Research. For catchments from which perennial streams emerge, a full water balance may be drawn up, involving detailed measurements of rainfall, soil moisture and streamflow, and estimation of evaporation from meteorological variables. Techniques of stratification of rain-gauges have enabled rainfall assessment to a very high level of precision for annual, monthly and even daily totals. Autographic streamflow recorders have, where adequately maintained, provided equally precise measurements. The value of soil moisture sampling and of gypsum block profiles to 10 ft. depth, which at the Kericho and Kimakia catchments provide an independent check on the water budget, has been emphasized by the impossibility at Mbeya of soil sampling to depths greater than $3\frac{1}{2}$ ft., due to a stone layer; in consequence discrepancies in the water balance cannot be resolved from the data available and further gypsum block and piezometer tube measurements must be undertaken.

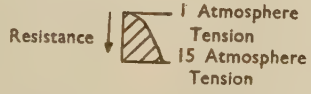
Catchment characterization by relation of storm runoff to incident rainfall

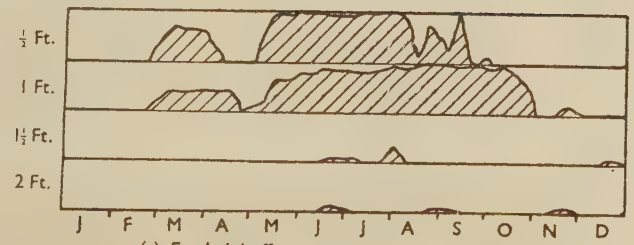
In underdeveloped countries where the cost of major water storage structures is prohibitive, it is essential that the land use management should aim to reduce the proportion of rain which is lost immediately as stormflow. Catchment behaviour in this respect can be tested independently of the overall water budget by comparing the stormflow response to individual storms. Indeed in extreme cases, such as in Karamoja where a water balance is completely impossible, the main criterion of the effect of changed land use is the direct relationship of storm runoff on intensity and amount of rainfall. In the East African Catchment Experiments, stormflow, (y), has been shown to be related to rainfall, (R), soil surface water storage, (S), and mean rainfall intensity, (I), as follows—

$$y = f(I)\,(R - S)$$

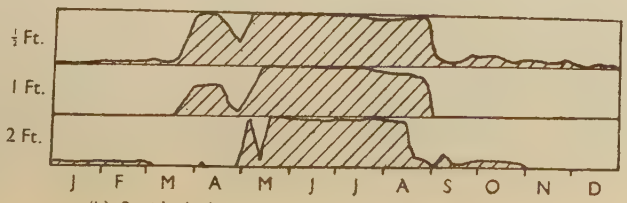
where the units are inches over the catchment. The quantity (R – S) is the "effective" rainfall, i.e. actual rainfall less the amount of water which will be absorbed in the topsoil surface litter and small surface depressions. The maximum value of S is the intercept with the rainfall axis, of a simple rainfall/runoff graph for storms following a period of dry weather. The actual deficit, subject to



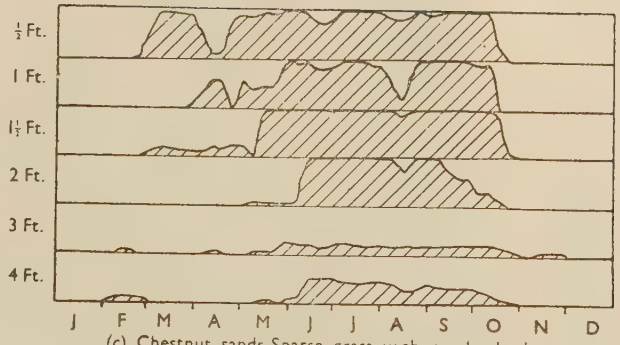




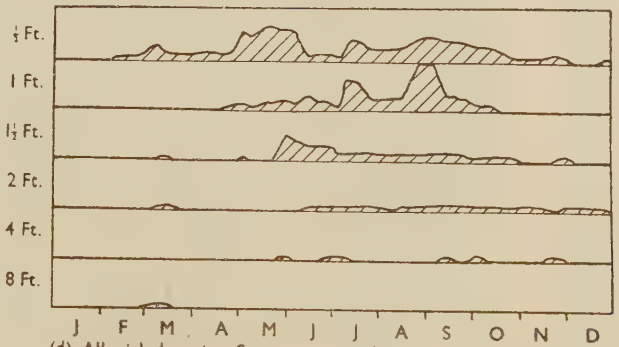
(a) Eroded buff-orange sandy loam. Bare soil.



(b) Residual clay with stone mantle. Sparse grass cover.



(c) Chestnut sands. Sparse grass with nearby bushes.



(d) Alluvial deposits. Sparse grass with nearby bushes and trees.

Fig. 1.—Penetration of rainfall into overgrazed grasslands (Karamoja)

this maximum value, may be estimated adequately from weather records for the few days prior to the storm. The dependence of runoff on rainfall intensity may be determined for a catchment from a study of the stormflow under wet conditions when the soil surface storage is zero. For this study, a mean rainfall intensity, weighted by the proportion of the total rainfall in the different intensity classes, was found most satisfactory.

Application of these techniques has shown that tall montane rain forest (at Kericho) and the bamboo forest (at Kimakia) are both efficient regulators of stormflow; in both cases direct runoff amounted to only some 1.5 per cent of the annual rainfall. On the other hand the overgrazed semi-arid catchments in Karamoja resulted in 40 per cent of the annual rainfall being lost as surface runoff. Table 1 summarizes the division of one year's streamflow into baseflow and stormflow at Kericho. The prediction equation was derived from a selection of storms and then applied to the remainder.

Depth of rainfall penetration

On the Karamoja catchment area experiment, gypsum blocks have been used to study depth of penetration of rainfall, and duration of availability of soil moisture at different depths. Twenty profiles of units were installed under different soil surface conditions in 1958; a selection of results is shown in Fig. 1, the shaded areas in the figure representing water available to plants. Fig. 1 (*a*) illustrates conditions under a heavily sheet-eroded orange sandy loam, which is typical of large areas of both catchments. Some 26 inches of rain, received over a period of seven months, did not succeed in penetrating to a depth of 18 inches. A quantitative study of these records provides a minimum value of storm runoff of 33 per cent of rainfall; this is in reasonably good agreement with the overall figure of 40 per cent obtained from a study of rainfall/runoff relationships.

Fig. 1 *b* and *c* show that for some other soil types, more limited in area, water penetration is better. But for the deep alluvial deposits, which might have been expected to provide a regulating reservoir for the stream, penetration was extremely poor, due to a tight clay band in these soils at about 18 in. depth. Fig 1 *d* illustrates how this acts as an aquaclude. Further details of these studies are to be found in the Special Issue; it may be concluded here that the techniques of gypsum block analysis are adequate to reflect any significant changes in rainfall acceptance due to changes in land use management.

TABLE 1—STORMFLOW FROM CATCHMENTS WHILE FORESTED—KERICHO

November 1957 to October 1958

Catchment	Streamflow in inches over catchment	Baseflow in inches over catchment	Measured stormflow in inches over catchment	Predicted stormflow in inches over catchment	Stormflow as % of streamflow	Rainfall in inches	% STORMFLOW / RAINFALL	
							Mean	Maximum individual value
LAGAN (Control) ..	11 35	10·37	0·98	0·91	8·60	77·56	1·26	2·97
SAMBRET	9·53	8·68	0·85	0·80	8·92	70·89	1·20	3·33

Irrigation and Crop Water Use Trials

M. Dagg, P. H. Hosegood, J. A. Forsgate, assisted by Samuel Kinyali and Jacob Mudiango

Crop water use trials at Perkerra, Kenya, and Mbarali, Tanganyika, mentioned in last year's Record of Research were initiated in 1961. At Perkerra a uniform star grass cover was established over the plots, and intensive soil sampling determined the initial soil moisture deficit. Subsequent water applications have been measured on to the 24 plots using cipoletti weirs equipped with autographic float recorders. Mr. R. G. Hosen of the Kenya Department of Agriculture has supervised the grazing of the plots by uniform herds of cattle, which are weighed regularly to ensure adequate liveweight gain. The results of the experiment will be assessed in terms of beast grazing days; additional information on the grass production is being obtained from bulk samples of grass cut from each main plot before grazing and from 1/40 acre ungrazed subplots inside each plot. Subsamples are taken for drying and crude protein analyses are carried out by the Grassland Research Station, Kitale.

At the Mbarali Irrigation Scheme in Southern Tanganyika, four watering schemes were proposed to test the applicability of Penman Estimates of Evapotranspiration, as applied to cotton; unfortunately the first year's results on the water use of cotton were completely inconclusive. The land allocated for the experiment on the trial farm was known to have a coarse sand layer at a depth of about 4 ft. but it was hoped to confine the water applications t othe top 4 ft. In the event, the importance of using gypsum blocks to describe the moisture status of the whole soil profile was clearly demonstrated when artesian water was shown to be reaching the experimental plots along this sand layer, thus vitiating any results based on differential watering treatments. The gypsum block records also helped to explain some unexpected results of previous experiments in that area. New plots have now been laid out on another area, following an extensive auger study of the soil to a depth of 6 ft., to confirm its reliability for experiments on rate of watering.

Dr. Dagg paid a visit to Zanzibar Department of Agriculture to advise on research methods and instruments for experimentation on the water use of irrigated crops in Zanzibar. In his report, a survey was made of the potential irrigation need for Zanzibar and Pemba.

Dr. McCulloch and Dr. Gwynne were invited to discuss a watering trial of pineapples being planned at the Horticultural Research Station, Thika, and prepared a memorandum for discussion. In consequence E.A.A.F.R.O. contributed to the experiment in studies of rooting depths of pineapples, of the leaf catchment behaviour, and in assistance in setting up the necessary agricultural meteorological instruments for estimation of potential evaporation.

In co-operation with Mr. Wallis of the Coffee Research Station, Ruiru, sixteen soil moisture profiles to $10\frac{1}{2}$ ft. were taken immediately after an application of water on the coffee irrigation trial at Jacaranda to study the distribution of applied water and to check on the calculated estimate of water required.

A series of undisturbed soil cores were taken to calibrate certain Uganda coffee soils in preparation for soil moisture studies of irrigation requirements of *Coffea robusta,* which are being initiated by Mr. Butters and Dr. Dancer of the Department of Agriculture Experimental Station at Kawanda. The problem is one of improving coffee bean quality rather than quantity.

Evapotranspiration tanks

Results are now available for a period of operation with the new method of measurement of water use by float. Four replicate tanks of star and guinea grass showed most satisfactory agreement when compared on monthly or yearly totals.

TABLE 2—MEASURED WATER USED IN INCHES
(mean of 4 tanks)
PERIOD 1–4–60 TO 31–3–61

	Rainfall	Eo (sunken pan)	Water used	Et/Eo
Star grass	21·53	72·56	40·11	0·55
Guinea grass ..	21·53	72·56	40·41	0·56

Table 2 shows the close agreement achieved between means of replicate tanks, although the water used was low when compared to Eo, despite inadequate surrounds and considerable differences in height. The star grass has been kept clipped to a height of about 6 in. while the guinea grass stand is about 3 ft.

Considerable experience has accumulated from this series of studies of different techniques of evapotranspiration measurement from tanks, and a separate report is being prepared for publication.

Evapotranspiration Measurements on Kikuyu Grass

Re-analysis of past experimental work at Tigoni has shown that the water use of Kikuyu grass (*Pennisetum clandestinum*) is similar to that of large plantation trees and bamboo thicket.

During a period of 336 days from 1st March, 1953, to 31st January, 1954, the gypsum blocks at depth recorded no through drainage, but blocks placed throughout the profile recorded two periods of moderate stress of about 60 days each, although frequent re-wetting of the top soil guaranteed available water. Kikuyu grass used 28.71 in. of water with an Et/Eo ratio of 0.85. The ratios for Radiata pine, Monteray cypress and bamboo thicket are respectively O.85, 0.86 and 0.85. A brief outline of the results of many years of research in the water requirements of East African crops has been prepared by Dr. H. C. Pereira and members of the Physics Division as a chapter in a forthcoming *Handbook of the Natural Resources of East Africa.*

TABLE 3—EFFECTS ON RAINFALL ACCEPTANCE OF TILLAGE IMPLEMENTS WHEN INCORPORATING MULCH GRASS

Implement	Rainfall acceptance in in./hr. of storm of 6 in. /hr.		
	Mulch	No Mulch	Means
Handfork	5·0	5·2	5·1
Modified Rotavator	5·6	4·3	5·0
Means	5·3	4·8	

Least significant differences within table = 0·6 (P. = 0·05).
= 0·8 (P. = 0·01).
Least significant difference between means = 0·4 (P. = 0·05).
= 0·6 (P. = 0·01).

SOIL PHYSICS

M. Dagg, P. H. Hosegood, assisted by Samuel Kinyali, Wallace Gichuru and Jacob Mudiango

During the year the processing facilities of the soil physics laboratory were doubled due to installation of new commercially available pressure membrane equipment for wilting point determinations and to completion of development work on a new type of perspex tray low tension apparatus for field capacity measurements on undisturbed soil cores. A substantial volume of samples

was processed in conjunction with the catchment experiments, with irrigation experiments and with the soil physical experimentation mentioned elsewhere.

A series of replicated profiles of soil cores to 10 ft. depth were taken from pits in plantations of Patula and Radiata pine and from bamboo thicket in the South Kinangop and Kinale Forest areas, in continuation of a comparative water use study of softwood plantations and Bamboo Forest (Pereira, H. C., and Hosegood, P. H,. 1962, in the Press). Assistance was also given to E.A.A.F.R.O. Forestry Division in their "Time of Planting Experiment" by weekly soil moisture sampling as a check on the "rainfall build up calculations". The estimated soil moisture build up agreed with that found by direct sampling.

The first cycle of the terracing and ley-arable trial at Muguga, described in previous Annual Reports (*see* 1953, p. 56) has been completed and a separate report on the conclusions reached is being prepared. Very little runoff through the outlet flumes was ever observed despite the decline in rainfall acceptance detected in laboratory tests. A striking observation was the heavy runoff that occurred from a recently grazed ley plot where no runoff was observed from the arable plots. Consequently, these plots are all being converted to leys and will be used in a new investigation of the effect of intensity of grazing on runoff.

The experiment near Arusha on the effects of a tie-ridged cultivation system on soil water relations and weed control (E.A.A.F.R.O. Record of Research, 1960, pp. 13-14) has been continued for a further year in co-operation with the Tanganyika Agricultural Department. Widespread drought and theft unfortunately prevented any quantitative comparison of yields being made. The early establishment of the maize crop was reported to be much better on the tie-ridged plots and cobs were formed (only to be stolen) whereas on the flat cultivated plots the plants formed no cobs. In accordance with the previous year's results, water penetration was much better on the tie-ridged plots than on the flat.

A long-term experiment on the effects of different tillage treatments in coffee on the soil structure has recently been brought to a close after three 5-year pruning cycles of coffee involving 30 cultivations. The final results support the earlier conclusions based on the first five years' data (*Emp. J. Exp. Agric., 22,* 1954, 231), that frequent clean weeding caused a deterioration in structure as compared with two cultivations a year and that the hand-fork maintained the rainfall acceptance of the soil better than a disc or

mouldboard plough. A comparison of the hand-fork with a rotavator, modified to leave large clods, in the presence and absence of a 4-in. deep elephant grass (*Pennisetum purpurem*) mulch gave the interesting interactions shown in Table 3, demonstrating that the ability of the modified rotavator to incorporate coarse fibrous mulching material into the top 3 in. of soil, has a most important effect on rainfall acceptance. The full details of this experiment will be published shortly.

A preliminary survey of forest sites in Kenya and Uganda was made with a view to an investigation of the effect of current softwood plantation practices on the rundown of the soil, structurally and chemically. It is hoped to take samples at one time from several plots at different stages in the forestry cycle, all on the same soil type but a preliminary sampling in Kenya revealed such a high degree of variability that this scheme may not prove practicable.

Soil Moisture Under Roads

Spot soil moisture samples taken under road surfaces in different parts of Kenya by the Tropical Section of the D.S.I.R. Road Research Laboratory of the U.K., indicated that a more detailed long-term study of soil moisture movement under road surfaces in tropical conditions would be of great value in gaining a better understanding of substratum conditions. E.A.A.F.R.O., with its pool of laboratory assistants trained in soil moisture study techniques, is situated on an important soil type and a co-operative experiment involving the Road Research Laboratory, the Materials Branch of the Kenya Ministry of Works and the Physics Division of E.A.A.F.R.O. has been set up on the Muguga Estate. The object of the experiment is to follow the pattern of soil moisture changes under a typical road pavement and to investigate the effects of different verge covers on this pattern. A new section of road was constructed in February, 1961, by the Ministry of Works under the guidance of Mr. F. S. Strongman and some 206 gypsum resistance units, together with 21 tensionmeters and 12 thermistors, were installed in suitable profile positions across the road and in the verges to depths of 10 ft. The experimental arrangement includes two shoulder slopes each with three verge treatments comprising deep rooting Kikuyu grass (*Pennisetum clandestinum*), a 2-in. layer of gravel chips with grass excluded and a layer of p.v.c. sheeting at a depth of 6 in. Teff grass (*Eragrostis abyssinica*) was planted on top of the p.v.c. sheeting. In addition three horizontal extension gauges were placed across the road at a depth of 1 ft. in an attempt to detect any relative horizontal movement between the road pavement and the shoulders. Five vertical extension gauges were also

installed to detect any shrinkage in the first 15 ft. of soil; three of these were under the centre of the road and two in the verges. The installation of the instruments was supervised by Messrs. Russam and Jones from the Road Research Laboratory and routine observations twice a week are the responsibility of Physics Division staff. The extended drought resulted in few changes and it is too early yet to reach any conclusion about differential rainfall penetration under the recent wet conditions.

Agricultural Meteorology

J. S. G. McCulloch, assisted by E. S. Waweru and P. N. Nganga

Catchment meteorological analyses dominated the year's work and resulted in substantial contributions to the Special Issue of the *East African Agricultural and Forestry Journal* in assessment of rainfall and evaporation for each of the catchment areas. In addition routine training of agricultural meteorological staff was undertaken at Muguga as well as routine visits for inspection and repair to catchment and other meteorological stations.

The general use of Gunn Bellani distillation radiometers, sponsored by this Organization (Record of Research, 1955, p. 10) has been endorsed by a Resolution of the 1st Interafrican Hydrology Conference, Nairobi, 1961. A further recommendation that calibration of radiometers be undertaken at a "central observatory in each geographical region" has been implemented by comparison running of the radiometers alongside an Eppley Pyrheliometer at the Headquarters Observatory of the East African Meteorological Department, Nairobi. The resultant data are plotted and analysed at E.A.A.F.R.O.; these calibrations have proved quite a sizeable task, which is undertaken in order to extend the network of solar radiation stations in East Africa.

Radiation studies at Muguga have been extended following receipt of additional apparatus as a gift of the Munitalp Foundation. Some of the equipment has yet to arrive but the sensing elements for total and net radiation have been used for spot observations throughout the day.

Estimation of evaporation by means of the Penman equation and studies of the dependence of the estimate on the meteorological variables inherent in the equation have been continued. Copies of Penman tables have been made available to various users, and research continues into water losses from evaporation pans as a function of calculated potential evaporation.

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT MUGUGA, 1961

	Rainfall	Air Temperature			Air Humidity			Wind Speed	Sun-shine	Open Water Evaporation			
		Monthly Means of Daily Values								Monthly Totals			
	Monthly Totals	Max.	Min.	Mean	Dew Point Mean of 0830 and 1600 hrs.	Saturation Mean of 0830 and 1600 hrs.	R.H. at 1600 hrs.	Mean Wind Speed at 6 ft. above ground	Mean Daily Sunshine hours	Sunken Pan Air Insulated from soil	Australian Pattern 3 ft. deep sunken tank	Raised Pan with light grid cover	Class "A" Pan
	Inches	°F	°F	°F	°F	mm. of Mercury	%	M.P.H.	Hours	Inches	Inches	Inches	Inches
January	0·26	75·9	52·5	64·2	48·7	6·51	36	9·0	10·7	8·63	8·68	10·42	11·03
February	0·28	76·8	51·9	64·4	48·7	6·62	35	8·8	10·0	8·01	8·53	9·58	10·27
March	2·74	75·3	54·8	65·0	51·1	6·14	41	10·2	9·7	8·94	9·08	10·80	10·27
April	6·62	71·2	55·0	63·1	54·8	3·74	45	8·0	8·1	6·33	6·31	6·77	6·68
May	3·85	70·8	54·2	62·5	55·3	3·26	37	6·3	8·1	5·48	5·52	5·98	5·94
June	0·62	69·3	50·4	59·9	51·6	3·40	36	6·2	7·3	4·78	4·58	5·61	5·35
July	1·05	67·8	49·7	58·8	50·0	3·45	35	6·3	6·2	4·42	4·25	5·06	4·87
August	1·00	66·0	50·4	58·2	51·4	2·71	39	5·6	3·2	3·38	3·46	3·76	3·57
September	1·29	67·9	50·9	59·4	50·7	3·48	33	7·0	6·5	4·85	4·77	5·41	5·28
October	6·46	70·1	52·9	61·5	53·1	3·61	36	8·6	6·9	5·96	5·85	6·37	6·32
November	21·93	66·6	53·3	60·0	55·7	1·87	45	6·5	5·1	4·50	4·53	4·36	4·56
December	13·57	69·0	52·1	60·5	55·6	2·15	35	4·2	5·0	5·55	5·38	5·23	5·22
Annual Total	59·67	—	—	—	—	—	—	—	—	70·83	70·94	79·35	79·36
Annual Average	—	70·6	52·3	61·5	52·2	3·91	38	7·2	7·2	—	—	—	—
Average Total	38·62 (11 yrs.)	—	—	—	—	—	—	—	—	65·63 9 (yrs.)	62·43 8 (yrs.)	72·28 (9 yrs.)	80·71 (4 yrs.)
Average Mean		70·0 (9 yrs.)	51·9 (9 yrs.)	60·9 (9 yrs.)	52·2 (9 yrs.)	3·65 (9 yrs.)	—	7·1 (9 yrs.)	7·3 (9 yrs.)	—	—	—	—

Dr. Pereira's memorandum on rainfall build-up in fallow soils was supplemented by a detailed set of rules and a tabulation format for easy calculation. The technique, which enables bare soil evaporation to be taken into account while rainfall figures are summed, has been tested at Muguga with encouraging results.

Assistance was given to Pasture Research Officers of the Kenya Department of Agriculture on the subject of temperature measurements in bush fires. B.A.S.F. thermopaints proved suitable for observations of accuracy adequate for the purpose. It became evident that the major problem in any such assessment is the statistical one of stratification and of replication. In any bush fire the variation in temperature from one place to the next is considerable and is undoubtedly of much greater importance than the uncertainty in the thermopaint observation due to time of exposure to heat, etc. The field work of this investigation was carried out by Mr. M. A. C. Pratt and the results are available as a departmental memorandum.

Vegetation Studies

O. Kerfoot assisted by Eliud Mungai

Limuru Tea Shade Experiment, 1958-61

The Limuru tea shade experiment, originally laid out by Dr. J. S. G. McCulloch with the assistance of Mr. N. A. Goodchild of the Tea Research Institute of East Africa, was wound up in February. The experiment was designed to measure the effects of shade and non-shade (as distinct from shelter which, perforce, had to be ignored) on the growth and production of green tea leaf. The compilation of two years' experimental data was completed by March and the data submitted for final statistical analysis. It is apparent that there is a markedly significant difference between the gross amount of leaf produced by the shaded bushes as compared with that from the unshaded; the latter giving consistently higher yields during the peak seasons of the year. The history and results of the experiment are now being prepared for publication.

Root Systems of Tea and Shade Trees

The study of the roots of tea bushes and shade trees was summarized briefly in the 1960 Record of Research, and reported on more fully in the Proceedings of the Seventh Conference of the Tea Research Institute of East Africa, 1960. Volumetric soil samples from estates at Mufindi in Tanganyika have been taken

and are now being dispersed, and the estimation of the volumes of tea and shade roots respectively is being continued for the range of sites investigated. The Tea Research Institute of East Africa and Messrs. Tanganyika Tea Estates are bearing the major cost of the effort and labour involved. It is now very apparent that many of the hitherto widely accepted criteria governing the growth and development of root systems will have to be modified or abandoned in the light of these researches.

Description of Catchment Area Vegetation

The preliminary surveys of the plant cover of the four major catchment areas have now been concluded. As far as Mbeya and Kericho are concerned, the collections of vascular plants may be regarded as representative and complete. The written summaries are included in the comprehensive account of the Catchment Area Research programme at present in the Press. An account of the plant ecology of the high altitude catchments with comparative analyses is in course of preparation. These areas probably represent the most intensively studied vegetation zones of any in East Africa. Root dissections of indigenous high forest trees in the catchments have been continued. At Mbeya, one of the commonest species *Apodytes diminiata,* has been excavated to a depth of 25 ft. with a lateral root range exceeding 35 ft., penetrating the highly metamorphosed schistose and gneissic basement complex strata. In riparian situations these root systems must have direct access to the perennial flow of water; a feature of the water balance which frequently receives scant attention in forest hydrological research.

The vegetation survey of the Kedong Ranch has been continued through a range of different seasons.

Measurement of Atmospheric Moisture

The measurement of atmospheric or "occult" moisture, not normally registered in the standard rain gauges, has been inaugurated. Fog-catching gauges have been designed and constructed at Muguga and a pilot trial established. Preliminary results indicate that these gauges intercept considerable quantities of moisture catches, up to three times the amount recorded in a standard gauge being achieved. With the co-operation of the Kenya Forest Department, a comprehensive experiment is being laid out in forested land to convert these qualitative measures of mist precipitation into quantitative amounts of water intercepted by a forest canopy. This has involved design and construction of drip gauges and stem flow gauges suitable for the conditions obtaining in a forest stand.

Statistics

J. S. G. McCulloch, assisted by E. S. Waweru and J. Adenya

The Head of the Division, Dr. McCulloch, continued to give statistical advice to officers on the station, and the statistical section carried out innumerable computations and calculations in consequence. Two papers are in course of preparation with Dr. L. M. Talbot on the application of body measurements for game animals to estimation of biomass. Heart girth is the best single body measurement for estimation of body weight, but in general the regression has a fairly high regression constant; the use of a volume index such as heart girth squared times total body length has resulted in a more promising and more general relationship. This work has proved of interest to the Animal Husbandry Division and is, with their co-operation, leading to further kindred papers. Statistical advice to the Kenya Forest Department on the use of regression techniques for estimations of timber defect allowances resulted in a memorandum which proved entirely acceptable to both the Forest Department and to the Lumbermen's Association.

Mr. E. S. Waweru visited West Kilimanjaro to give computational assistance to the Animal Industry Division in association with the Tanganyika Agricultural Department.

Visitors and Scientific Liaison

During the year a number of visitors spent extended periods working in the laboratories, to become familiar with the Research techniques in use in the Physics Division. Dr. P. E. van Niekerk, Director of Horticultural Division of Western Province Fruit Research Institute of South Africa, Stellenbosch, was interested in soil physical calibration for irrigation purposes; M. M. Aldegheri, Hydrologist with O.R.S.T.O.M. of Madagascar spent a month studying laboratory and catchment research techniques sponsored by F.A.M.A.; Mr. B. D. Soane of the Federal Ministry of Agriculture of Rhodesia and Nyasaland, Mr. B. Boaler, Colonial Fellow in Tanganyika, and Dr. Jelley of the Kafue Pilot Polder, Northern Rhodesia spent shorter periods in the Physics Division laboratories. Messrs. Russan and Jones of D.S.I.R. Road Research Laboratory, worked with the Physics Division while establishing the Road Research Experiment. Advice on specific problems was given to numerous other visitors from the East African Territories and Overseas.

Scientific Liaison

The Division contributed materially to the CSA/CCTA Hydrology Conference in Nairobi in January. Dr. Pereira was

rapporteur for the Plenery Session on the effects of land use policies and Dr. McCulloch was rapporteur for the meetings on rainfall and evaporation. Dr. McCulloch and Dr. Dagg took part in an irrigation symposium sponsored by the Kenya Department of Agriculture. Prior to Dr. Pereira's departure an interterritorial symposium for agricultural research officers was held at Muguga to discuss research techniques in soil moisture studies. Dr. McCulloch attended the World Meteorological Organization Radiation Symposium at Vienna in August and Mr. Kerfoot, on leave from April to September, visited Near East research establishments and botany schools and studied semi-arid and arid zone reclamation projects and ecology. In addition he paid a short visit to the mountain forests of Cyprus.

PLANT PHYSIOLOGY

J. Glover

The plant physiologist was on overseas leave for most of the year so this report refers mainly to work conducted during the first four months. During this period drought studies were carried out in co-operation with Dr. M. D. Gwynne of the Oxford University School of Botany.

DROUGHT AND PLANT BEHAVIOUR

Studies of the drought tolerance of maize and changing metabolic behaviour as water supply is restricted were continued. Unfortunately the natural drought which is frequently encountered during the period January-March was much more severe than usual and plants at all stages of growth were rapidly killed. The metabolic changes were so rapid that with our limited facilities for chemical analyses we were unable to study the pattern in detail. In general, as already described in the Annual Report for 1960, there is a transport of materials from older to younger tissues to help with their survival. It is apparently inadequate to cope with the severest drought we have encountered.

The severe drought provided a practical test of the results of earlier studies of stomatal behaviour in maize (*J. agric. Sci.* 53:412 (1959)) which had indicated that even severely droughted young plants could recover after the drought had broken because the unexposed leaves can then develop normally as they are only seriously damaged shortly before the plant dies of drought. We showed that this is so by selecting at random rows of young maize of different ages in the field plots and giving them sufficient water to wet the soil down to some 3 in. below the surface in simulation of light showers. The plants recovered fairly easily and carried on growing until the soil was again exhausted or they had reached vegetative maturity.

The small amounts of water required to keep the plant alive and growing prompted the investigation of light rainfall as an aid to plant survival. Hitherto, in considering the rainfall regime of a maize crop, we have neglected the light showers of 0.1 in. or less which are re-evaporated from the soil in a few hours. We now find that significant amounts of rainfall can be intercepted by the plant and stored in a hemispherical zone at the base where the roots can make use of water, even though the soil is air dry only a few inches away from the base of the plant. For example, a shower of 0.03 in.

of rain, which in bare soil was re-evaporated within an hour, provided over 100 millilitres of water by stem flow to the dry soil at the base of a plant some 6 ft. tall. This gave a hemisphere of wetted soil of some 6 cm. radius which was a significant contribution to survival since much was stored below the level of immediate evaporation. Indeed the plant drew upon it for several days by which time it was replenished by another light shower. It therefore seems reasonable to assume that small showers can be a very valuable aid to survival of a crop like maize and they should not be neglected when considering rainfall during drought periods. The full details of this work are published in *J. Ecol.* 50 : 1.

Preliminary surveys show that a wide range of plants can intercept and store light rainfall in useful amounts. In some cases, as with the fire-resistant tree *Balanites aegyptica,* the accumulation of water in the soil near its base is of value to other plants and may play an important role in thicket formation.

PLANT COMPOSITION AND ANIMAL NUTRITION

The joint work with Dr. H. W. Dougall of the Grassland Research Station, Kitale, has continued. We have been concerned with the changing chemical content of a wide range of fodder crops as affected by drought and rain. The gross metabolic changes are now becoming more clearly understood and the differences between genera and species are showing remarkable constancy which will aid the interpretation of the physiological behaviour of the crops as well as their value in animal nutrition. This work is also closely connected with the more detailed metabolic studies conducted by Dr. Gwynne. A series of papers was published which deals with different aspects of the problem.

CHEMISTRY

SOIL AND PLANT STUDIES

H. F. Birch and C. C. Hood

1. *Phosphorus Transformations*

The work in progress during 1960 on phosphorus transformations during plant decomposition was completed during 1961. A summary of the results follows:—

During plant decomposition the inorganic water-soluble phosphorus originally present in the plant is rapidly converted to microbial organic phosphorus. Subsequently, with young plant material, much of this microbial organic phosphorus is reconverted to inorganic phosphorus following death and lysis of the microbial cells. With mature plant material there is little reconversion even after three months' decomposition, regardless of whether the organic phosphorus content is higher or lower than that of the young material. Decomposition of the mature material is more prolonged than that of young material and it is probable that a viable population continues to utilize inorganic phosphorus produced by lysis. Alternatively, different microbial populations may have been operative. While qualitative tests showed that bacteria were present in all instances, this does not rule out the possibility that fungi were also present and more active with mature than young material (*see* final paragraph of this section). With neither young nor mature plant material is more inorganic phosphorus produced than is originally present in the plant even after three months' decomposition.

The enzymatic conversion of microbial organic phosphorus back to inorganic phosphorus involves first the hydrolysis of acid-labile forms (ribose-3 phosphate, adenosene-3 phosphate and guanosine-3 phosphate), and then of acid-stable forms (mucleic acids and phospholipids) which, together, account for all the microbial organic phosphorus. With young plant material the residual unhydrolysed microbial organic phosphorus (i.e. the fraction remaining after decomposition that has not been re-converted to inorganic phosphorus) consists of about 70 per cent acid-labile and 30 per cent acid-stable phosphorus. With mature plant material approximately equal parts of each form are found. Acid-stable phosphorus is hydrolysed after five days with N sulphuric acid at 100° C. The amount initially present in this form in plant material was found to be quite small and less than the total plant organic phosphorus.

The organic phosphorus compounds reaching the soil after plant decomposition appear, then, to be a mixture of enzymatically decomposable acid-labile and acid-stable forms of microbial origin and more difficultly decomposable organic phosphorus compounds of plant origin which resist prolonged hydrolysis with hot N sulphuric acid. These compounds are, however, also liable to decomposition as shown in section 3 (humus decomposition).

Exposure of the samples at progressive stages of decomposition to chloroform vapour results, during the first five days or so of the decomposition process, in rapid and almost complete enzymatic hydrolysis of microbial organic phosphorus to inorganic phosphorus with young plant material, and partial conversion with mature material. This difference may be due to the presence of fungi (which do not hydrolyse with formation of inorganic phosphorus following exposure to chloroform vapour) during the decomposition of the mature material. Plating of the samples during decomposition showed, however, that bacteria were largely operative in all instances. Since enzyme activity of bacteria declines with age, the amount of inorganic phosphorus produced after exposure to chloroform vapour is a useful technique for following such changes.

2. *Nitrogen Fluctuations in Grasses*

This work is being carried out in conjunction with Dr. W. H. Dougall of the Grasland Research Station, Kitale. The primary object of the work was to study the effect of stage of growth on the decomposition and mineralization of organic nitrogen of grasses. Results of additional interest were, however, obtained which, as far as we are aware, have not hitherto been reported. A short account follows.

Two perennial grasses, *Brachiaria ruziziensis* and *Setaria sphacelata,* were sown at the same time in adjacent field plots at Kitale. The first samples were taken after six weeks and subsequently at weekly intervals. The whole plant was taken at approximately 1 in. above the soil at the different growth stages, dried, milled and analyzed.

Throughout the period (6-21 weeks) the *Brachiaria* samples showed little variation in the amount of ammonia – N that could be extracted with water, namely about 30 mg./100 g. air dry material, or in pH (using a 1 : 100 plant-water ratio) which ranged between 6.2 and 6.4. With *Setaria* a completely different pattern of

behaviour occurred as shown in Fig. 1, in which pH values have also been converted to mg. H^+ ions extracted per 100 g. material. The regression equation (1) of H^+ on NH_4—N (each expressed as mg./100 g. of plant material) was positive, linear and highly significant ($r^2 = 0.948$).

$$H^+ = 0.000355\ NH_4\text{—}N + 0.0053 \ldots\ldots (1)$$

The regression line passes almost through the points of origin and the interesting feature is that accumulation or loss of ammonia is accompanied by an almost strictly proportional gain or loss of some acidic constituent or constituents. A direct significant relationship over the same period was also obtained between ammonia and titratable acidity.

Comprehensive data are lacking on which to base an explanation of the results summarized in Fig. 1. Since, however, the two grasses were of similar chemical constitution and ash content it is

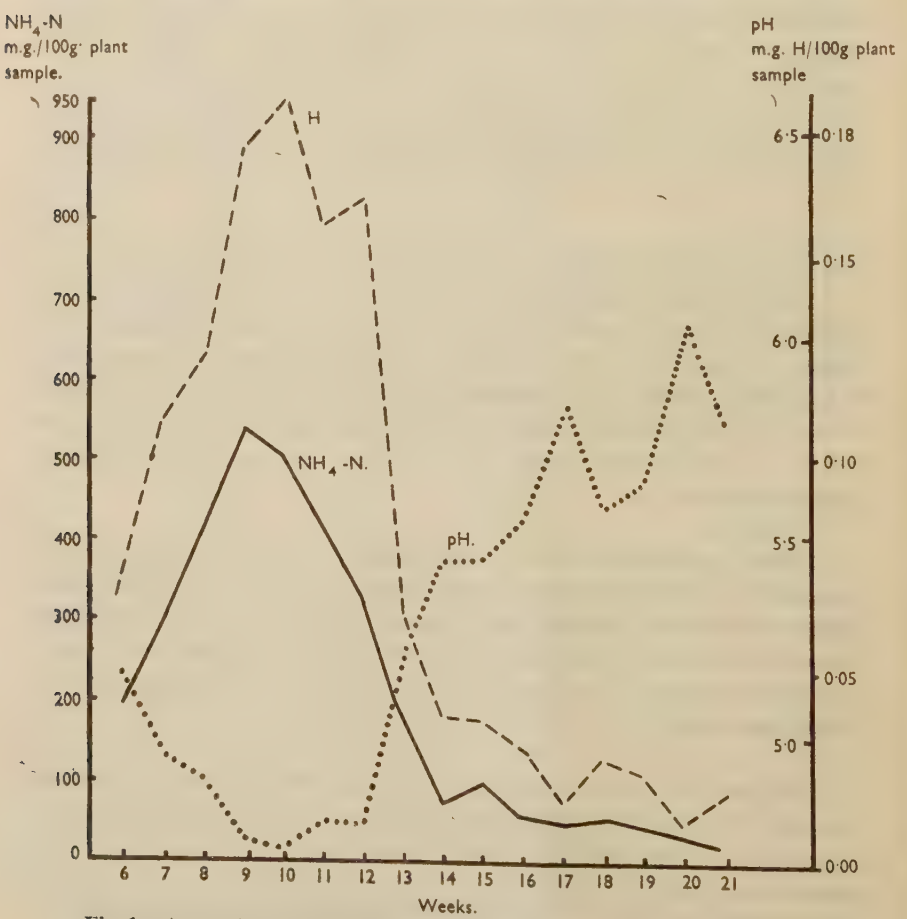


Fig. 1.—Ammonia, pH and H+ changes during growth of *Setaria sphacelata*

assumed that ammonia was taken up by each in approximately equal amounts. The rise and fall with *Setaria* is considered, therefore, to result from changes within the plant during growth. From the highly significant level of equation 1 it is evident that the same reaction operates during the rise and fall of ammonia and associated changes. The dissociation constants of the acids during this period were found to be approximately constant and similar to those for amino acids. The operation of the following reversible reactions would be in accord with these observations.

$$\text{Protein} \rightleftharpoons \text{R.CH.NH}_2\text{COOH} \rightleftharpoons \text{R.CO.COOH} + \text{NH}_3 \text{ or}$$

$$\text{Protein} \rightleftharpoons \text{NH}_2\,\text{CO.R.CH.NH}_2\text{COOH} \rightleftharpoons \text{HOOC.R.CH.NH}_2\text{COOH} + \text{NH}_3$$

Reversible reactions of these types are known to occur in plants. With *Setaria* it appears that at week six, or earlier, breakdown of protein occurs to amino acids and/or amides. These, in turn, are partially converted to keto acids, or dicarboxylic amino acids, and ammonia. This would account for the build-up of ammonia, while the presence of increasing amounts of undissociated amino acids and/or acid amides would account for the concomitant decrease in pH or increase in titratable acidity. At about the ninth or tenth week the reverse reaction begins to take place with regeneration of protein and a decline in ammonia and amino acids and/or acid amides and therefore in pH and titratable acidity.

Decomposition over a period of 14 days showed similarity of behaviour with the two grasses both as regards mineralization of organic carbon and nitrogen and the decline in the amounts mineralized with maturity. During the first three days of decomposition, however, there was an uptake of ammonia with the *Setaria* samples, collected between weeks 6 and 13, but not with the *Brachiaria* samples, decomposition of which also began considerably earlier. This difference in behaviour is related to the lower pH of the *Setaria* samples (6-13) since qualitative tests (kindly carried out by Mr. R. N. Gourlay of the East African Veterinary Research Organization) showed that under the more acid conditions bacterial development was hindered and the development of fungi (which tolerate lower pH conditions and utilize more ammonia than bacteria) was enhanced. Although the two grasses contain approximately the same amounts of organic nitrogen they differ markedly during a certain stage of growth in their ammonia and amino acid contents which, in turn, affects their decomposibility. This may be reflected in differences in their values as feeds.

A further result of interest was the high nitrate content of both grasses, particularly between weeks 6-16. The highest level was

reached with *Brachiaria* and was equivalent in terms of nitrate-N to about 5.9 per cent of potassium nitrate on a dry matter basis. This is within the toxic range in relation to the occurrence of methemoglobemia in cattle, and may be worth further study. The high nitrate contents in the two grasses may have been due to the abnormally long dry season with consequently high nitrate production at the start of the rains.

3. *Humus Decomposition*

A soil containing 8.15 per cent organic carbon was submitted 204 times to the following cycle—

(*a*) moistened to field capacity;

(*b*) allowed to decompose for five days at 25° C.; and

(*c*) oven-dried at 100° C. for 48 hours.

Analyses revealed that 63.5 per cent of the organic carbon, 46.4 per cent of the organic nitrogen and 100 per cent of the organic phosphorus, originally present, had been mineralized. The resistance of the organic carbon and nitrogen compounds to a combination of hydrolytic (during drying) and microbial decomposition processes is noteworthy. Experiments showed that potentially the whole of the soil organic phosphorus is fairly readily decomposable by micro-organisms. Either the soil organic phosphorus compounds are less complex than the soil organic nitrogen compounds, or are more accessible to the micro-organisms.

ANALYTICAL CHEMISTRY

SPECTROCHEMICAL SECTION

G. T. Chamberlain, A. J. Searle, P. K. Patel, M. B. Lamb and Chege Mugane

Development of Techniques

Developments in technique during the year have consisted of the introduction of a new step filter to the trace element technique which now enables 12 samples to be determined simultaneously compared to nine previously. The spark method for calcium and magnesium has been used as required and the Division has received an EEL flame photometer, thus allowing the return of the instrument on loan from the Kenya Department of Agriculture.

Investigations have been carried out into the effect of large concentrations of one trace element on the determination of another, this from the aspect of the appearance of weak spectral lines not of sufficient intensity to interfere under normal circumstances. Simultaneously the opportunity was taken of studying the magnitude of errors arising in certain stages of the spectrographic evaluation technique. In particular the suitability of palladium as an internal standard and the correlation between analytical and internal standard spectral lines under arc conditions were investigated.

Cations in Soils

One hundred and eight samples have been analyzed for cations of which 33 were for the E.A.A.F.R.O. Soil Survey Division. Resulting from the formation in 1960 of the Analytical Subcommittee for the determination of plant nutrients, 30 samples were analyzed for comparison with determinations made by other cooperating laboratories. The work for this Subcommittee is described by Mr. Friend. The remaining samples were for territorial departments or connected with trace element investigations.

Trace Elements in Soils and Plants

Continuing the work reported last year, further samples were collected for the Uganda Forest Department from the Imatong Mountains. The Spectrochemist visited the area in March and samples of *Callitris* spp. were collected from these research plots in the Imatong Mountains and one near Gulu. Poor growth resulting in trees appearing more as ornamental bushes seems to be a result of both nutritional and mycorrhizal problems. Soil potassium is very low at 0.5 m.e./100 g. soil or less while soil calcium varies

from 7 to 15 m.e. per cent. The trees are slowly growing out of this condition, the improvement being more marked where mycorrhizal formation was taking place, and was least marked on the high calcium soils. There was also a growth response to an NPK fertilizer. Very low foliar Mg. concentrations were also found, although the exchangeable magnesium varied between 1-3.6 m.e. per cent. The three species analysed were *C. hugelii, C. endlicherii* and *C. preissei*. For all elements except molybdenum the species did not differ noticeably but in each plot the *C. hugelii* had consistently higher concentrations.

Also for the Uganda Forest Department, analyses were made of soils in the Usi area of West Nile where Cypress was growing poorly. The soils were found to be of low base status and very acid, but they also had a high level of readily extractable heavy metal ions, including chromium, cobalt and nickel. In fact, two of the samples gave 1.5 p.p.m. of chromium, the highest amounts yet recorded for an East African soil.

Further samples of *P. radiata* from the Lushoto area were submitted by the Tanganyika Forest Department, these being from selected trees treated with applications of borax. The indications found in 1960 that boron deficiency might be the cause of die-back are confirmed. Trees showing die-back had 3-8 p.p.m. boron in the needles while healthy trees resulting from borax applications contained more than 20 p.p.m.

For the Tea Research Institute, Kericho, Kenya, samples of tea and eucalypt were analysed. The high aluminium content of the tea leaf rendered the normal concentration technique unsuitable in some instances. However, the direct burn of plant ash revealed a magnesium deficiency in some samples.

An investigation of the effect on pineapple of heavy nitrogen applications being carried out by the Kenya Department of Agriculture provides an opportunity for studying the behaviour of the nutrients in this plant. During the year, the first batch of 24 samples was analysed for the range of trace elements determined in this laboratory.

The analysis of samples collected during a visit to the Northern Rift Valley area of Tanganyika during 1960 were completed. Grass samples from Magara at the southern end of Lake Manyara were definitely deficient in cobalt (<0.05 p.p.m.) and copper (3-5 p.p.m.). Grasses from the Bashanet area were also deficient in copper but marginal in cobalt. The soils of the Magara area did not, however, indicate cobalt deficiency as 0.4-0.8 p.p.m. Cobalt was soluble in acetic acid. This problem has meen met before in the Laikipia area

of Kenya on a completely different soil type. Bean samples from Magara and Monduli showed very lown boron concentrations. A further series of bean samples have been received from a boron and zinc fertilizer experiment at Magara. Lucerne grown in the Babati area of the Rift Valley was very low in magnesium, manganese and boron.

An interesting, although not unexpected, feature of soils in the Lake Manyara area was that the molybdenum extracted by E.D.T.A. was much lower than other lake areas analysed. The low molybdenum values are due to the siliceous nature of the basement complex rocks in this area, whereas previous samples from lake areas (Naivasha, etc.) have been from volcanic ash or lava soils.

A programme of monthly samples of coffee leaf supplied by the Lyamungu Research Station, Tanganyika, has begun. These samples consist of control and suspect samples from the Mbozi area. Thus far, eight batches have been analysed and in every instance the boron and iron concentrations in the unhealthy samples have been considerably lower than the controls. Borons in the healthy range from 80 to 180 p.p.m. compared to 30-50 in the unhealthy. The iron values are about 200 p.p.m. for healthy leaf and 100 p.p.m. for unhealthy leaf.

A further series of grass samples from an animal nutrition experiment have been analysed for the Animal Health Research Centre, Uganda. Also 26 samples of sisal were analysed for the Sisal Research Station, Mlingano, Tanganyika.

Kenya Coffee Analyses

The analyses carried out by Mr. Lamb will be fully reported in the Annual Report of the Coffee Research Station, Ruiru, Kenya.

During the past year samples analysed have been taken from an Irrigation Trial and Manurial Trial being carried out at the Coffee Research Station.

A continuation of the study of the seasonal variations of trace and major elements in coffee leaf throughout Kenya has taken place with the help of Coffee Research Substations and estates where nutritional defects are suspected.

GENERAL ANALYTICAL SECTION

M. T. Friend and Leonard Nganga

Ammonia and Urea Estimations in Urine

In co-operation with the Animal Husbandry Division, methods were developed for the rapid determination of ammonia-nitrogen and urea-nitrogen in cattle urine. Colorimetric methods were not

satisfactory and the Conway Microdiffusion technique was adapted to suit the quantities and concentrations encountered. For ammonia-nitrogen 1 ml. of the urine sample is used in the Conway Unit and 1 ml. of diluted (× 50) urine is used for urea + ammonia-nitrogen. For ammonia-nitrogen the standard deviation of the method was 0.53 mg. NH_3-N per 100 ml. urine and was 16 mg. N per 100 ml. urine for the ammonia plus urea determination.

It was also found that, unless very considerable precautions were taken, the ammonia content of urine collected over a 24-hour period was high due to the hydrolysis of the urea, and it was therefore necessary for the sample to pass directly into a container in which 250 ml. of 2N sulphuric acid had been added. This proved satisfactory in preserving the sample and the ammonia value did not increase when the acidified sample was allowed to stand for periods up to 24 hours.

Calcium and Potassium in Plant Material

A visit was made to the Grassland Research Station at Kitale to study the determination of calcium in plant material. The standard oxalate-permanganate method, an E.D.T.A. method, and a flame photometric method were compared on a set of six grass samples. All methods gave good agreement, but the flame photometric method gave slightly more variation in results and necessitated a separate wet-ashing of the sample. The E.D.T.A. method was the quickest and most consistent of the methods.

Analytical Subcommittee

Thirty soil samples were distributed by Mr. A. N. Smith of the Tea Research Institute, Kericho, for analysis by various laboratories in East Africa. The analyses carried out were for carbon, nitrogen, phosphorus, sulphur, pH, exchangeable Ca, Mg, K, Na, H. The results of the analyses then available were discussed at the Senior Chemists Conference at Muguga in May. The completed results from the seven participating laboratories have been collected and, as decided at the Conference, passed to the Scott Agricultural Laboratories for statistical analysis. pH determinations in particular were made in a variety of ways by different laboratories. At E.A.A.F.R.O. these pH determinations were repeated using different proportions of soil to M/100 calcium chloride solutions. The ratios chosen were: 1:10, 1:7.5, 1:5, 1:2.5, and the strength of the M/100 $CaCl_2$ solution was also varied by ± 1 per cent. In all these estimations, the greatest difference in pH for any one soil was 0.2 pH units. The use of M/100 $CaCl_2$ is therefore preferred to soil: water suspensions, where changes in the ratio of soil to water give greater pH differences.

Water Uptake by Forest Soils

Some of the changes that occur in forest soils when the indigenous bamboo cover is replaced by softwoods have been studied. The changes appear to be more of a physical than chemical nature and it has been found that a dry topsoil from under bamboo takes up water under a 2 cm. tension at a very much slower rate than an adjacent topsoil from under pine plantation. If, however, the soil from under bamboo is alternately dried, re-wetted and allowed to decompose in the macro-respirometer, dried again and this cycle repeated several times, then its rate of water uptake approaches that of the topsoil from under pine. This suggests that some fraction of the organic matter that is easily decomposable is responsible for the almost water-repellant properties of some of the topsoils under bamboo.

E.A.A.F.R.O. Animal Husbandry Division

The determination of inorganic phosphorus contents of blood samples from a herd of identical twin cattle has continued at three-weekly intervals throughout the year.

E.A.A.F.R.O. Soil Physics Section

The oven-dry weights of silt samples from weirs in the Kimakia, Kericho and Mbeya catchment areas have continued to be measured together with the organic matter content of bulked samples. In all, 234 samples have been received. A further 37 soils were analysed for sand, silt and clay contents.

Forty-two soils from deep pits at Cheke Forest Station and South Kinangop were analysed for carbon, nitrogen and pH in connexion with the run-down of forest soils.

Desert Locust Control

Nineteen soil samples from the Somali Republic have been analysed for gravel, coarse sand, fine sand, silt, clay, pH, carbon, nitrogen, organic matter, water soluble salts, sulphur, calcium carbonate and exchangeable calcium, magnesium, sodium, potassium and hydrogen.

Ecological Survey of Masailand

As part of an ecological survey of Masailand being made by Dr. P. E. Glover of the Kenya Veterinary Department and Dr. M. D. Gwynne of the Botany School, Oxford, 274 soils have been received for analysis. The determinations made were coarse and fine sand, silt, clay, carbon, nitrogen, organic matter, pH, and exchangeable sodium and potassium.

ECOLOGY

C. G. Trapnell

VEGETATION—LAND USE SURVEY OF SOUTHERN KENYA

This project was outlined in the last Annual Report. Its practical objective is the mapping of the complex climatic zones of Southern Kenya for land-use purposes. Its primary scientific aim is a fuller understanding of the relations of vegetation types to climate, involving a critical study of the effect of grouping meteorological data against precisely mapped vegetation zones. Major soil factors are also being taken into consideration, more particularly in the part which they play in differentiating vegetation boundaries. Very few regional studies of the climatic relations of vegetation have been attempted in Africa and it is hoped that the work will throw new light on the climatic regimes as well as on the agricultural potential of the region concerned.

This project is now at the end of its second year. Ground traverse work and air photograph interpretation were continued during the year through the North Nyanza and Rift Provinces with a smaller personnel than in the previous year. Mr. W. R. Birch, Pasture Research Officer of the Kenya Agricultural Department, remained with the survey through the whole period. During the first three months valuable help was given by Mr. D. J. Pratt, Pasture Research Officer of the same Department, who carried out the mapping of the difficult and dissected country of the South Baringo basin, of which he has special knowledge. The writer was also engaged on survey work, but was occupied for two months on other duties, and absences due to short leave and sickness have also to be allowed for. The effective strength of the survey over the year was therefore barely two officers. Further help, however, was kindly provided by the Directorate of Overseas Surveys in the form of advance plottings of remnant forests and bamboo areas over a number of sheets. In the outcome the area covered by field work and photograph interpretation amounted to 14,000 square miles. The full area covered to date stands at 34,000 square miles, out of the projected total of 42,000 square miles, but this will be reduced to 41,000 by a modification of sheet lines.

This rate of coverage involves full ground traverse work, stereoscopic examination of all air photographs and plotting of the boundaries transposed from them on to the 1/50,000 maps, i.e. to a scale of over an inch to the mile. Except in areas where

interpretation is obscured by factors such as heavy cultivation, the plotting of boundaries has been kept accurate to within a quarter of a mile. This small margin of error should disappear at the scale of 1/250,000, to which the maps will finally be produced. It will be found in the final maps that the amount of detail which requires to be shown varies considerably in different regions. The greatest complexity is involved in areas of steep elevation and pronounced orographic variation of climate, as in Kamasia or Machakos, and also in areas where former forest land or evergreen bushland have been overrun by other types of vegetation. Large tracts in the Lake Victoria basin, on the other hand, will emerge on a much broader zonal pattern. Certain variations of vegetation in this region, and in some other heavily cultivated areas, are only partially capable of air photograph interpretation. The degree of detail in which these areas can be mapped is dependent on the amount of ground observation which can be accomplished, and in some cases sub-types will have to be denoted by symbols.

Concurrently with the mapping work a full analysis of the available climatic data is being carried out by Mr. J. F. Griffiths of the East African Meteorological Services. This involves some 650 recording stations of eight years' standing or over, and the precise positions of these are being checked on the 1/50,000 maps. The data being collated include altitude, mean annual rainfall, rainfall/altitude ratio, monthly mean and percentage monthly rainfalls, together with temperature data where available. The figures will subsequently be grouped under the vegetation zones to which they apply, with a view to obtaining a firm basis for definition of their climatic significance.

It is hoped to complete this work and the outstanding field work which remains in the Central Province before the end of March, 1962. The writer will then be proceeding on leave pending retirement and Mr. Birch will also be taking leave before returning to his Department. The largest share of the mapping work has been in his hands and it is thanks to his able and unflagging help through the last two years that it is now within sight of completion. Remaining air photograph interpretation and plotting on 1/50,000 sheets not completed by March will be carried out in Britain. It will then be necessary to edit the 136 sheets on this scale for the reduced compilation at 1/250,000. The final compilation and production on four contoured sheets is being undertaken by the Directorate of Overseas Surveys. The maps are due to be accompanied by a descriptive memoir incorporating the ecological and climatic data. As there is a large amount of information to be collated for this purpose, publication of the completed work is not anticipated before July, 1963.

VEGETATION TYPES OF EAST AFRICA

No general account has hitherto been available of the overall pattern of East African vegetation. The chief additional commitment during the year was the preparation of a condensed outline of the more important vegetation types for the forthcoming *Handbook of Natural Resources of East Africa,* in so far as they can be summarized from the numerous scattered publications on the subject. Any such outline must at present be based on a very broad physiognomic classification and this raises a number of long-standing problems of terminology and definition. A compromise classification has been worked out which incorporates what would seem to be the best points of the scheme adopted at the Specialist Meeting on Phytogeography held at Yangambi in 1956, and of that proposed by the earlier Vegetation Committee of the Interterritorial Pasture Research Conference in Nairobi, which was employed in Gillman's vegetation map of Tanganyika. Some discrepancies are unavoidable in any such attempt but it will at least provide a guide to the available literature. This account was drawn up in collaboration with Dr. I. Langdale-Brown of the Directorate of Overseas Surveys, and is accompanied by a physiognomic map prepared by him at the Directorate.

SOIL SURVEY

R. M. Scott and Stephen Kamau

Soil Surveys

The Directorate of Overseas Surveys has kindly undertaken to print the soil map of the Nairobi-Machakos areas. Initially, black and white copies of the eight 1/50,000 sheets will be printed and these should be available early in the New Year. When these have been completed a coloured version of the map on a scale of 1/100,000 is to be prepared to accompany the report.

Handbook on the Natural Resources of East Africa

A chapter on the soils of East Africa together with a soil map of East Africa on a scale of 1/4,000,000 has been prepared for this Handbook. The main difficulty when compiling a small-scale soils map is the presentation of as much information as possible in a readable form. In an attempt to overcome this, the soils have been grouped into soil-topography associations, which are based on Milne's "catenas"; for it appears that for each type of topographical landscape there is a definite soil sequence which is dependant on the climate and the parent material. In the map key the various soil-topography associations are illustrated and thus an idea of the topography as well as the soil sequences associated with it can be obtained. The soil-forming factors, as they affect East African soils, are also discussed in the text.

Soil Changes under Softwood Plantation Cropping

The Soil Survey Division has been co-operating with both the Chemistry and Physics Divisions in selecting sites for this investigation. Unfortunately, there was a great divergence between the soils under the various covers to be compared in all the sites visited. The main reason for this being that the different covers to be compared were separated from each other by considerable distances, it not being possible to find comparable covers adjacent to one another. The distance between sites also affected the climate and the parent material of the soils in the areas visited. The climate is affected owing to steep ridged topography on mountain slopes where slight differences in altitude may lead to great differences in rainfall. The parent material may also vary since, in the areas visited, the soils are derived from a series of volcanic ash showers giving rise to polygenetic soils. Unless the sites investigated are near to each other, the surface soils may be derived from ash showers of different ages.

Studies on Soil Properties

Having completed the study of the relationship between rainfall and the percentage saturation of mature well-drained soils, the relationship between some of the common exchangeable bases, namely calcium, magnesium and potassium, are now being studied.

So far, a relationship has been found between exchangeable calcium and magnesium and these in turn have shown a relationship to percentage saturation and total exchangeable bases. However, as yet no relationship has been found with exchangeable potassium.

Special Issue of East African Agricultural and Forestry Journal on the Catchment Area Experiments

Reports on the soils in the experimental catchment areas of both Kenya and Tanganyika have been written up for this issue. An interesting feature common to these catchments is the presence of polygenetic soils.

Soil Survey of Kedong Ranch

A base map for the soil survey is now being produced with the aid of aerial photographs. When this has been completed the field work will begin.

SORGHUM BREEDING RESEARCH

H. Doggett and D. Jowett

This Division works at the Serere Experiment Station belonging to the Uganda Department of Agriculture, and we remain indebted to the Director and his staff for all the facilities they have put so freely at our disposal. The immediate general policy of this Division is to look into the possibilities of producing palatable sorghums which store well, which will suffer considerably less bird damage and give appreciably higher yields than the existing sorghums. The general lines along which the first of these problems is being tackled is to work out the genetics of a range of characters each of which is likely to decrease the attractiveness of the developing grain to birds, and then by combining together as many of these characters as possible in the same plant, to test how far they reinforce each other to produce a sorghum relatively resistant to serious loss of yield due to bird damage. Arising out of this general problem, work is also proceeding on the anatomy of the seed coat of sorghum grain and the inheritance of its various characters. We hope ultimately to combine a corneous endosperm, which promotes weevil resistance of the grain when in the store, with the bird resistance of the brown grained types. These two characters have not so far been found together, and it is possible that if they can be combined it will be easier to devise machinery to remove the bitter endosperm. If this can be done we would finally hope to combine this grain type with all the other characters which reduce the severity of bird attack, so that we can produce sorghums having a really high degree of resistance.

The second major aspect of the work concerns the possibility of breeding sorghums giving an appreciably higher yield than existing varieties. This is involving a study of the yield potential of "hybrid sorghums" which have been produced in other countries and also of the posibility of obtaining a hybrid autotetraploid which will maintain the yield increment due to hybrid vigour for a much longer period than the single generation of normal diploid hybrids.

Growing Conditions

Serere shared the unusual weather experienced over the whole of north-east Africa in 1961. Rainfall was low in the early rains, and the crop showed diurnal wilting during some periods. However, heavy rain commenced at the end of June and continued until mid-December. Harvesting of the first rains crop was made difficult, and the second rains suffered from an excess of moisture and low

insulation throughout its growing period. Ripening was delayed and it is feared that much of the grain harvested in the second rains will not germinate.

The moist conditions in the second rains gave rise to epidemic conditions for leaf diseases. The main causative organisms were *Colletotrichum graminicola, Helminthosporium turcicum* and *Puccinia purpurea*. The rust was the least severe of the three, but this year pustules were seen on the upper leaves, whilst usually they are restricted to the lower worn-out leaves. It was particularly interesting to observe the varying degree of resistance to leaf diseases of the varieties being bulked. The SB varieties bred by Doggett from Dobbs × P 127 ex-Swaziland, together with Dobbs itself, were defoliated and the grains failed to fill properly. Tada was also defoliated, but filled its grains better, probably owing to its earlier maturity. Framaida showed severe rust but nothing else, and damage to the crop appeared slight. The American Pearl Kafir, Grohoma and Socner Durra Milo, the South African variety Bird-proof and L 28 (ex. Lango, Uganda) showed slight rust only. The variety 42b, bred by Doggett for corneous grain, remained virtually free of all diseases.

The Varietal Collection

All varieties including new acquisitions from Nyanza Province, Kenya and Karamoja were grown out as short rows in the first rains. The collection continues to expand and it will be a relief when cold storage facilities enable us to keep seed for several years. Lack of staff again prevented much work on assessing varieties, but a number of promising varieties were harvested and bulked up on $\frac{1}{4}$-acre isolation plots in the second rains. Seed will therefore be available for demonstration plots, and we hope to plant a few trials with these varieties. Should any variety prove to be an improvement we should then endeavour to arrange for it to be bulked for distribution.

During the year 16 requests for seed of varieties held by us have been received. We were able to fill all these requests.

Breeding for Bird Resistance

One side of this work is to produce satisfactory sorghums possessing the three properties of large glume, goose-neck and long awn. We have a large glumed line 56 × 53, but it has many poor plant characters. Last year a number of crosses were made aimed at introducing a longer awn, and above all the goose-neck or Korgi habit into this line, and the F1 generation was grown out in the first rains this year. All available heads were selfed and in addition all F1's were backcrossed to both parents. The appearance of some

of these Fl plants was very pleasing. In particular crosses between Korgi and several of Doggett's lines were far superior in appearance to either parent. Many rows having Korgi or SB 230 as parents showed 100 per cent goose-neck.

It was interesting to observe that wherever the large glume line 56 × 53 was used in a cross, the F_1 strongly resembled the other parent. The 56 × 53 lines are very poor apart from possessing the large glume. It would seem that they possess a considerable assemblage of recessive genes, and this in itself could be responsible for their poor plant characteristics.

The F_2 generation of all crosses, together with first back-crosses, was grown out in the second rains. Some of the crosses can certainly be rejected on the basis of their F_2 performance. Others show promise. In particular, there would seem to be little possibility of getting large improvements in awn length. The 56 × 53 material shows a fairly long awn, and in fact is probably comparable in length with that of BC_2BIKO, but the lower end of this awn is hidden in the glumes. Most of the parents are awned, and it seems likely that a long awn can be readily selected out of any of the crosses, with the possible exception of Korgi crosses, without recourse to BC_2BIKO.

Goose-necked plants were frequent in the F_2 populations, and particularly so where SB230 was a parent. This was combined with some large glume in many plants. Selection will now proceed for these characters. Whether the goose-neck will prove heritable must await the results from F_3 rows. The fact that the best goose-neck crosses involve SB230 is interesting, as this variety possesses an extremely short peduncle. Goose-neck has in the past been a difficult character to select for, and selection could be simplified if it could be shown that the character is related to something measurable such as short peduncle. Measurements were therefore taken of peduncle length on plants showing a variable degree of goose-neck in a range of crosses. In every cross investigated the mean peduncle length was shorter in goose-neck plants. Data are given in Table 1.

TABLE 1—MEAN PEDUNCLE LENGTHS IN Cms. OF GOOSE-NECK AND NON-GOOSE-NECK PLANTS IN SEVERAL CROSSES

Cross	Parents	GN.	No. GN.	Cross	Parents	GN.	No. GN.
OJX1–6	SB229, 56x53	40·6	61·8	OJX70	SB230, 54xGN	28·7	38·5
OJX7–12	SB230, 56x53	34·8	49·3	OJX71–73	SB230, 54x34	33·9	43·7
OJX14–21	Korgi, 56x53	35·3	53·7	OJX74–76	SB230, 55x69	29·6	55·3
OJX60	SB229, 54xGN	32·6	46·9	OJX77	SB230, 53x37	29·9	35·6
OJX61–63	SB229, 54x34	37·3	60·7	OJX79	SB230, 56x25	33·4	44·9
OJX64–66	SB229, Korgi	29·6	42·2	OJX80	Korgi, 54x9	35·9	42·9
OJX67	SB229, 53x37	32·8	37·5	OJX82–83	Korgi, 54x34	36·2	50·6
OJX68	SB229, BC KOR	38·5	53·8	OJX84–86	Korgi, 55x69	37·2	54·6
OJX69	SB230, 54xGN	29·1	36·7	OJX87–88	Korgi, 56x25	44·5	49·4

These results do not prove conclusively that there is a causative relationship between goose-neck and short peduncle. Alternative explanations such as genetic linkage are possible. They do however give a basis for selection work. Other factors are undoubtedly involved, and it would be helpful if they could be elucidated.

Crosses between 56 × 53 and the cleistogamous Nunaba were also successful. Large glumed plants showing a fair degree of cleistogamy are appearing in the F_2. Crosses aimed at improving the plant characteristics at present associated with the large glume of 56 × 53 have been less pleasing, but will be carried on to the next generation.

The Inheritance of Awnless

F_2 and F_3 generations of the cross between the awnless varieties KA4 and L17 and the awned BC_2BIKO and IS2639 were grown out. The two generations were grown in successive seasons, not simultaneously. Mean awn lengths on the first head to appear were estimated for each plant. The results of the F_2 are shown as distribution diagrams in Figure 1.

The F_1 generation all showed short awns. The F_2 proportions of awned to awnless fit no known genetic ratio. The crosses involving the longer awned BC_2BIKO show too few awnless to fit a3-awned: 1 awnless and those involving the shorter awned IS2639 show too many awnless. The simplest explanation of this is that many genes are involved and that genes for the presence of awn must accumulate beyond a threshold value before awns develop. This can be tested by growing F_3 populations, where we might expect awnless plants to produce some awned progeny. The number of awned progeny would vary from population to population depending on the number of genes for awned possessed by the parent F_2 plant, and its degree of heterozygosity.

The F_3 population all showed longer mean awn lengths than their F_2 parents. The regression coefficients of F_3 mean on F_2 for the crosses BC_2BIKO × L17, BC_2BIKO × KA4 and IS2639 × KA4 were 0.77, 0.88 and 0.53 respectively. All awnless plants produced some awned progeny, and in many cases the majority of the progeny were awned. For this reason and because progeny awn lengths were generally longer than parental it appears likely that environmental factors are involved. The F_3 results therefore support but do not prove the explanation advanced on the basis of the F_2 results. In work of this kind it is essential to grow a full trial of all generations, properly replicated, in one season.

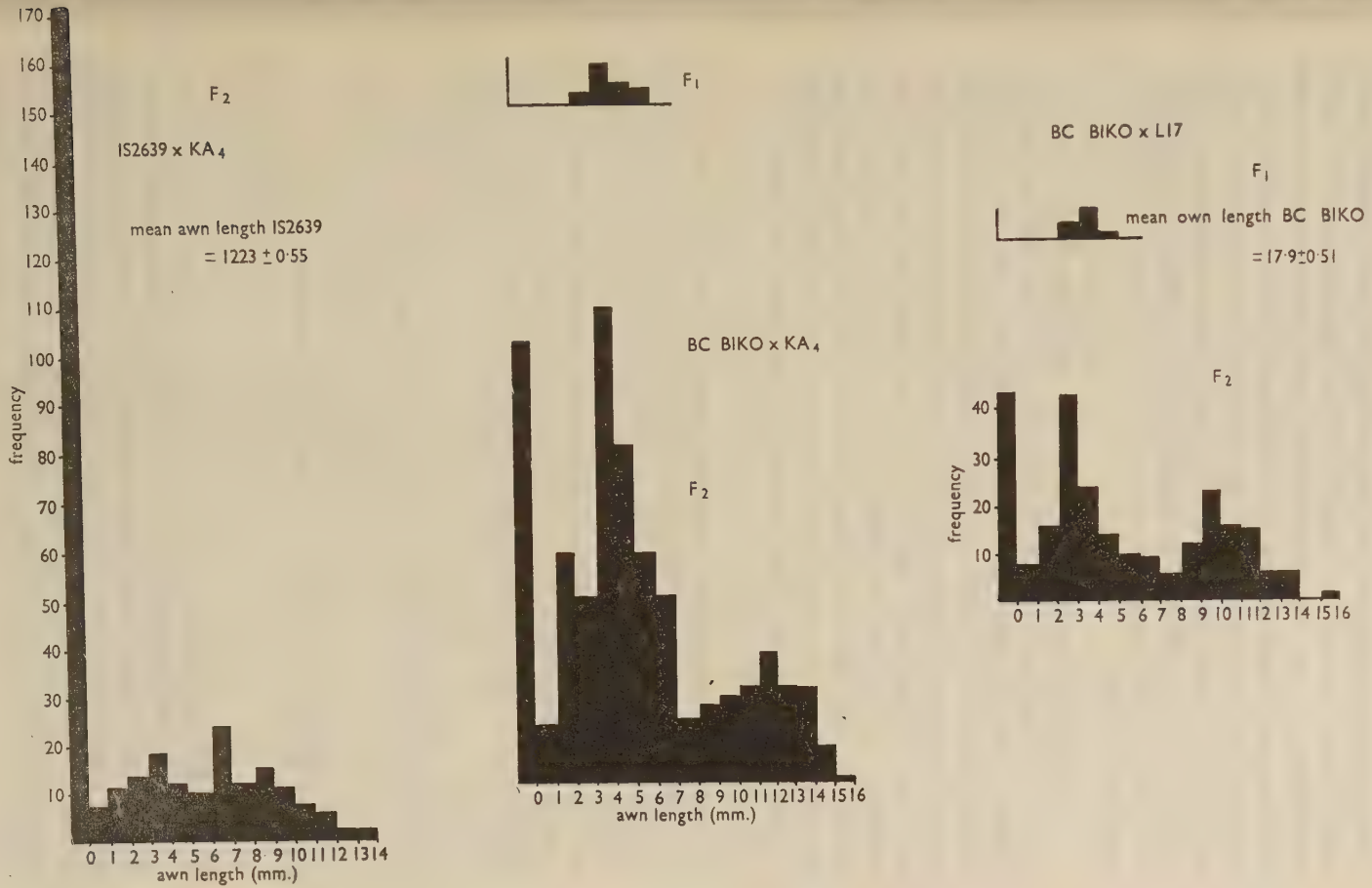


Fig. 1.—Awn length distributions in 3-awned × awnless crosses

The Genetics of Awn Length

In this investigation the long-awned BC_2BIKO was crossed with the very short awned variety R_2. The cross was made by hand-emasculating a few spikelets of an R_2 head. The remainder of the head was selfed and selfed seed from each of the parental heads bulked up to provide parental populations. Subsequently a larger quantity of F_1 seed was produced by hot water emasculation of R_2 plants, and the initial hybrid seed grown to produce an F_2 population. The F_2 plants were grown out and 23 of these were selfed to produce F_3 families.

In the second rains this year a trial was planted of all generations in 10 replicates. Each replicate was divided into 44 plots of 5 plants each. In each replicate 3 plots were allocated to each parent and the F_1, 6 plots to the F_2 and B_1 and 1 plot to each F_3 family. Awn lengths were measured on the first head to appear on each plant. The results are not yet complete, but the trial will ultimately be analysed statistically according to the method devised by Mather. The results at present available give a strong indication that awn length is controlled by several genes, and that short awn is generally dominant. Distributions of awn length in parents, F_1, F_2, B_1 and selected F_3 families are given in Table 2.

TABLE 2—AWN LENGTH FREQUENCY DISTRIBUTIONS (mm.) IN PARENTAL AND SUBSEQUENT GENERATIONS

Awn length (mm.)	Parents	F_1	F_2	B_1	F_3/1	F_3/4	F_3/5	F_3/6	F_3/9	F_3/12	F_3/14	F_3/17
2·4– 3·6	20	7	2	1	3							
3·6– 4·8	94	22	19	2	14						11	2
4·8– 6·0	20	12	27	8	17		3				6	4
6·0– 7·2		9	28	9	9		1				6	2
7·2– 8·4		13	35	10			4			1	6	6
8·4– 9·6		35	32	16	3		5			1	3	7
9·6–10·8		12	27	32	1		5	1		16	4	2
10·8–12·0		2	25	24			6	3	2	14	3	7
12·0–13·2			16	39		1	5	1	5	8	4	5
13·2–14·4	2		9	33		9	3	7	9	3	1	4
14·4–15·6	11		4	21		18	6	16	17		1	3
15·6–16·8	15		3	17		22	2	11	7			3
16·8–18·0	29		5	8		3	1	5	5			
18·0–19·2	33		2	5		2		2	1			
19·2–20·4	20		2	2		1						
20·4–21·6	4											

The Genetics of Large Glume

This investigation has followed the same lines as that on awn length. The original cross was between SB217 with large glumes and R_2 with short glumes. Parental, F_1, F_2, B_1 (backcross to SB217) and 30 F_3 families were produced. These were planted in a trial of 8 replicates, each consisting of 56 plots of 5 plants each. In each replicate 4 plots were allocated to each parent and the F_1, 8 plots to

F_2, 6 to B_1 and 1 plot to each of the F_3 families. Glume length and glume breadth were measured on the first heads to appear on each plant. The distributions of glume length for parents, F_1, F_2, B_1 and selected F_3 families are shown in Table 3.

TABLE 3—GLUME LENGTH FREQUENCY DISTRIBUTIONS (mm.) IN PARENTAL AND SUBSEQUENT GENERATIONS

Glume Length	Parents	F_1	F_2	B_1	$F_3/3$	$F_3/4$	$F_3/11$	$F_3/12$	$F_3/16$	$F_3/17$	$F_3/23$	$F_3/27$
3·6– 4·0	45		3							3		
4·4	66		5				2			3	4	
4·8	28		24	4		2	12			22	11	
5·2	3	8	32	10		4	16	3		3	9	
5·6		19	36	10	1	5	2	3..			3	
6·0		71	64	16	4	7	2	9			7	
6·4		44	38	22	7	6		9	2		3	1
6·8		7	43	24	10	6		5	4			2
7·2		14	10	20	4	2		3	4			1
7·6			13	8	4	3		3	2			
8·0			8	32	3	1		3	8			3
8·4			2	16	1			1	5			5
8·8			5	14				2	9			6
9·2				10					2			5
9·6			1	4					2			5
10·0			1	5								4
10·4	8			1								1
10·8	35			1								
11·2	20											
11·6	24											
12·0	10											

Again there are strong indications that several genes are involved and that small glumes are largely dominant. Data for glume breadth have yet to be sorted, but there will be an opportunity to see whether this most important character is inherited independently. In addition, 90 glumes, covering the range of sizes shown, were measured length and breadth and their areas estimated by counting squares on graph paper. From this data a regression was calculated as follows:—

$$\log A = 1.0691 + 1.1139 (\log L - \overline{\log L}) + 0.9603 (\log B - \overline{\log B})$$

where A = glume area, L = glume length and B = glume breadth.

By detransformation and simplification we get

$$A = 0{\cdot}5906\ L^{1{\cdot}1139}\ B^{0{\cdot}9603}.$$

It should therefore be posible to convert all plot means to glume area and analyse the data statistically.

Genetics of Grain Characters

Crosses between corneous white, non-corneous white, non-corneous brown and part-corneous pink-grained varieties were performed last year. This year F_1 and F_2 generations were grown out, and it is intended to study the genetic relationship between corneous endosperm and grain colour. However, grain quality is poor this year owing to the weather, and it is feared that the results may be inconclusive.

STRIGA RESISTANCE

The preliminary tests reported last year suggested that the Striga resistance of Dobbs was due to lower production of the stimulant necesary to germinate Striga seed. Further studies have shown that this is only part of the story. Dobbs does produce less stimulant than the variety Wiru, as reported last year, but it produces much the same quantity of stimulant as does the Striga susceptible variety Bukura Mahemba.

Table 4 gives extracts from germination tests, using Striga seed collected in the Lake Province of Tanganyika.

TABLE 4—GERMINATION OF STRIGA SEED BY DIFFERENT SORGHUM VARIETIES

Variety	TRIAL 1 18 replications		TRIAL 2 12 replications	
	Percentage *germination*	*arc sine*	Percentage *germination*	*arc sine*
Wiru	22·5	27·6	16·8	23·5
B. Mahemba	—	—	15·1	21·7
Dobbs	13·1	20·6	13·4	20·6
Framaida	5·5	10·8	9·9	16·6
Difference (D) at P = 0·05 (Modified Tukey)	—	5·4	—	3·0

The germination by Framaida, a Striga resistant variety from South Africa, is more variable in these tests than expected, which may be due to the material being heterozygous for this character.

Analysis of data collected in 28 trials in Tanganyika over several sites and 8 years showed that Dobbs consistently produces less Striga above ground than does Bukura Mahemba. Figures were:—

Variety	*Mean yield (grain)*	*Mean number of Striga per acre*
Dobbs	1,325 lb./acre	3,200
B. Mahemba	845 lb./acre	37,200

Further trials at Ukiriguru, Tanganyika, over five years showed that there are substantial yield differences under conditions where the crop was grown continuously, on land with a very high Striga population the Striga being hand weeded from some plots and left on others.

Variety	*Striga removed*	*Striga left*
Dobbs	367 lb./acre	301 lb./acre
B. Mahemba	256 lb./acre	91 lb./acre

The difference between the Dobbs yields under the two treatments is not significant, that between the B. Mahemba yields is significant beyond the P = 0.01 point.

Thus, the field resistance to Striga of Dobbs has been clearly established. It does not appear to be due to lower stimulant production at least in relation to B. Mahemba, though it may be a factor relative to Wiru. Therefore, it must be a type of physical resistance as postulated by Saunders for his sorghum varieties resistant to *S. asiatica,* the parasite being often unsuccessful in establishing itself properly on the host roots. It would evidently be valuable to have low stimulant production combined with this physical resistance. Crosses have therefore been made between Dobbs and Framaida to transfer this character of low stimulant production to Dobbs. In the second rains first backcrosses of the F_1 to Dobbs have been made.

SEED SET IN TETRAPLOIDS AND AUTOTETRAPLOIDS

The 4 N × 5 Cross

This cross was made in 1956 between two autotetraploid cultivated sorghum varieties, each of which showed a seed set of 30 per cent or less. A few selections from the F_7 generation of the cross were planted this year as F_8 progeny rows. Results are similar to those obtained last year, excepting that the general level of seed set is higher, as shown in Table 5.

TABLE 5

Family No.	1960 F_7	1961 F_8			
	Mean % seed set	Mean % seed set	Arcsine	5% confidence limits	No. of plants counted
9/3/2	75·3	81·0	64·4	± 0·55	147
26/6/2	72·5	77·8	62·1	± 0·66	141
39/37/1	71·5	78·9	63·1	± 1·69	43
34/12/1	65·6	79·3	63·1	± 0·84	44
3/8/1	69·5	76·1	60·8	± 1·60	36
26/10/4	68·9	78·6	62·7	± 0·60	125
26/10/2	66·8	69·8	56·7	± 1·40	43

The figures shown are means of the progeny of each family. Within families, individual progeny row means range from 65.3 per cent to 86.1 per cent and there are large differences in variance. Selection within this material should therefore result in further increases of seed set.

Autotetraploid Lines

It was suggested last year that genes affecting the seed set of tetraploid sorghums were distributed in the diploid population. It was also shown that the recent tetraploid species *Sorghum almum* had a variable but quite high level of seed set. This year several lines of *S. almum* and a number of autotetraploid cultivated sorghum lines were planted in a replicated trial. They were grouped as varieties (in the case of *S. almum*, families derived from last year's selections), and lines within varieties. A summary is given in Table 6. Those varieties not stated to be *S. almum* are cultivated autotetraploids, except N_1 diploid and SA2 diploid, which are controls.

TABLE 6—PERCENTAGE SEED SET FOR SEVERAL AUTOTETRAPLOID SORGHUM VARIETIES AND LINES OF S. ALMUM.

Variety and Line	% set	Arcsine	Variety and Line	% set	Arcsine
N_1 diploid	91·9	73·6	N_1 P_4 ..	63·9	53·1
Almum 16/3 ..	90·7	72·3	N_1 P_5 ..	63·5	52·9
Almum 8/2 ..	90·6	72·3	R_8 H_1 ..	63·3	52·7
SA2 diploid	90·4	72·1	Redlan H_3 ..	62·2	52·1
Almum 14/2 ..	90·3	72·0	R_1 H_2 ..	62·1	52·0
Almum 19/1 ..	89·6	71·2	Redlan H_5 ..	61·2	51·5
Almum 19/2 ..	88·8	70·5	P. Baker P_6 ..	60·7	51 2
Almum 2/1 ..	87·8	69·6	Natal Red P_1 ..	60·4	51·0
Almum 14/1 ..	87·1	69·0	SA2 H_6 ..	60·1	50·8
Almum 5/1 ..	86·4	68·4	Redlan H_1 ..	59·8	50·6
Almum 16/1 ..	84·9	67·4	R_1 H_1 ..	59·7	50·6
Almum 16/2 ..	84·4	66·8	R_1 P_9 ..	58·8	50·1
Almum 9/1 ..	84·2	66·6	R_1 P_6 ..	57·7	49·4
Almum 8/1 ..	83·8	66·4	B_9 H_1 ..	57·5	49·3
Almum 9/2 ..	83·1	65·8	B_9 T ..	56·5	48·8
Almum 5/2 ..	81·2	64·4	B_5 H_5 ..	53·4	47·0
Almum 2/2 ..	79·9	63·7	SA2 H_5 ..	51·9	46·1
T 32. H_1 ..	76·7	61·2	B_5 H_8 ..	45·7	42·5
Redlan H_2 ..	67·0	55·0	B_5 P_1 ..	42·1	40·4
N_1 P_1 ..	66·2	54·5	B_5 PF ..	41·1	39·9
R_8 H_2 ..	64·1	53·2			

Sig. diffs. at P = 0·05 (arcsine figures):—
2 adjacent means (P = 2) 5·16
2 means 10 places apart (P = 10) 6·08
(P = 20) 6·35
(P = 40) 6·50

In the subdivided analyses differences between varieties (and *S. almum* families) are significant, but differences between lines within varieties are usually not significant at the P = 0.05 level. The exceptions are Almum 2, Almum 8 and B_5. Thus there are apparently significant differences between the seed sets of various autotetraploid cultivated sorghum lines, and it is probable that these differences are genetic. Furthermore, the selection of *S. almum* lines having a seed set of the same order as that of the diploid cultivated sorghums is apparently quite straightforward.

S. almum Crosses

The first backcross generation of the cross tetraploid cultivated sorghum × (tetraploid cultivated sorghum × *S. almum*) was grown out, comprising some 40 backcross lines. High seed set continued to behave as a dominant character, and quite a number of these B_1 plants had seed sets recorded as over 90 per cent. It seems that there will be no difficulty in moving high seed set from *S. almum* on to the cultivated sorghums. Several of the B_1 plants were approaching cultivated types in grain, leaf and stem characters. The second backcross was made from the B_1 plants on to a wide range of cultivated sorghum varieties the object being to transfer high seed set to several sorghum groups, so that the eventual hybrids between them will bring in good seed set from both parents. The next stage is to get three or four more backcross generations grown as rapidly as possible.

YIELD POTENTIAL OF HYBRID SORGHUM

The eventual aim of the tetraploid work is to produce tetraploid sorghum hybrids which will retain their hybrid vigour over several generations. Clearly in view of the promising results from tetraploids outlined above it is desirable that we should begin to assess the value of diploid hybrids under East African conditions. Through the kind co-operation of the Departments of Agriculture in Uganda and Kenya we have been able to grow out a series of trials involving hybrids this year.

The trial consisted of 3 hybrids, 2 varieties and maize in 6 randomized blocks. The hybrids were RS610, a Texas hybrid which has proven itself in many sorghum-growing areas, Hazera 726 and Hazera 727, all seed being obtained from the Hazera Seed Co. of Israel. The variety Dobbs was also used in all trials. Throughout the Eastern and Northern Provinces of Uganda, except Busoga, the other sorghum was L28, a proven variety originating in Lango district. Elsewhere a local variety from the area in which the trial was grown was obtained. The maize in Uganda was a synthetic from Kawanda, 5354 RRM/58. In Kenya local maize was used, which at Kampi ya Mawe was Taboran, the new short-term maize.

The results are shown in Table 7, the yields being expressed in lb./acre. The results from Kenya clearly show the superiority of hybrids over varieties, and the maize comparison is also interesting. In particular the virtual failure of Taboran at Kampi ya Mawe compared with the best sorghum hybrid giving almost a ton to the acre is striking. Rainfall figures are available for Kampi ya Mawe by courtesy of Mr. Dowker. Only 9.44 in. fell from March to July inclusive.

TABLE 7—SORGHUM HYBRID VS. VARIETY VS. MAIZE TRIALS, 1961
(Yields in lb./acre.)

	RS610	726	727	Dobbs.	Local	Maize	L.S.D. 15%
Kenya							
Homa Bay	3,231	3,340	2,432	2,323	2,396	907	478
Mtwapa	2,458	3,173	1,615	1,437	2,058*	1,506	348
Kampi ya Mawe ..	1,888	2,058	1,550	1,227	1,793*	621†	342
Uganda N. Province							
W. Nile—							
Nebbi	134	637	369	720	771	620	414
Abi	1,109	948	1,180	1,048	680	576	376
Acholi—							
Labora	—	489	—	1,742	1,491	844	370
Lango—							
Ngetta	436	1,860	293	1,290	1,056	2,362	—
Aduku	—	—	—	667	560	1,541	523
Karamoja—							
Kotido	1,206	1,374	972	1,608	1,273	838	470
Uganda E. Province							
Teso—							
Katakwi	1,484	1,967	1,109	2,118	1,980	1,629	748
Kuju	938	2,078	1,106	1,910	1,608	1,240	380
Kumi	1,525	2,647	570	2,681	2,748	2,396	470
Bukedea	427	838	469	1,382	1,248	1,105	340
Serere	2,010	2,078	1,927	1,592	1,826	1,307	399
Bukedi—							
Budaka	2,949	3,385	2,530	3,401	3,435	2,631	595
Iki-Iki	875	1,146	791	1,367	1,200	1,320	638
Kibale	754	1,458	846	1,441	1,684	1,022	419
Kisoko	1,343	1,153	529	1,498	1,810	1,662	388
Busoga—							
Nakabango ..	1,240	1,649	885	3,194	2,272	5,335	441
Nawanzu	452	1,089	402	1,273	620	3,217	404
Bulopa	600	620	717	895	1,046	1,096	326
Uganda W. Province							
Ankole Rubare ..	1,072	871	402	1,273	1,340	2,346	387
Toro Kyembogo	2,161	1,810	352	2,949	3,334	4,407	713
Bunyoro Bulindi ..	2,379	2,815	1,474	3,183	2,144	2,949	581

*Tada. †Taboran.

In Uganda the situation is not so clear. All the hybrids proved particularly susceptible to Central Shoot Fly, *Atherigona indica,* and RS610 and 727 proved highly susceptible to bird damage. Where Striga was present, notably at Iki-Iki and Nebbi, infestation was far greater on the hybrids. Finally, the failure of the hybrids at Labora and Aduku was judged to be due to the Sorghum Midge, *Contarina sorghicola,* although the trials were visited too late in the season for certain diagnosis. However, in the most pest-free trials, notably Kuju, Kumi, Serere, Budaka, Kibale and Bulindi the hybrids showed up quite well. At Ngetta, where bird damage was severe only on RS610 and 727 the best sorghum was 726, which is the hybrid not damaged by birds. It is worth noting that the hybrids remained relatively free of leaf diseases wherever seen, presumably because resistance has been thoroughly incorporated by American breeders.

The maize comparison is even more difficult to summarize briefly. However, on the most fertile and wettest sites, Nakabango,

Nawanzu, Kyembogo, Bulindi, it far exceeded the sorghum yields. Under somewhat less favourable conditions, as in Teso district, the sorghum generally exceed the maize.

Hybrids of African Origin

The results of these American hybrid sorghum trials are considered promising, and they are to be continued and extended in 1962. However, their extreme susceptibility to pests strongly indicates the need for us to develop hybrids involving varieties better adapted to East African conditions. Two possibilities are available. We may cross African varieties possessing the fertility restorer gene on to the better American male steriles such as CK60A. Alternatively we may introduce cytoplasmic male sterility into those African varieties which do not possess the restorer gene and use them as female parents for varieties possesing the gene. The former alternative is clearly going to give us hybrids much sooner, if it produces successful results.

Preliminary observations from two crosses grown out in the second rains are available. The crosses made were CK60A × Dobbs and White Wheatland A × Dobbs, and the hybrids were found to be completely male fertile, showing that Dobbs possesses the restorer gene. Central Shoot fly and leaf diseases were severe this season, and CK60A and White Wheatland were badly attacked by the fly and Dobbs by the leaf diseases. The hybrids on the other hand seemed to be resistant to both and they produced healthy stands. If, as we believe, bird resistance is related to brown seed colour and particularly to the presence of a non-disintegrating integument, then bird resistance should be dominant and present in the hybrids. Prospects are promising, therefore, if a cross giving good heterosis involving an African male parent can be found. Unfortunately, complementary genes for height are present in Dobbs and American Dwarfs, and the resulting hybrids are much taller than is desirable. The problem of reducing the height of the hybrids should not prove insuperable.

In the second rains a series of the better varieties from the collection, including those being bulked for test, and covering the various types of cultivated sorghums fairly effectively, were grown out. Each was crossed to CK60A. This will enable us to study the distribution of the restorer gene and, by observation on single rows, to decide whether any hybrids of this kind are worth testing. In addition the non-male-sterile varieties have been extensively intercrossed, using the hot water emasculation technique. Observations on these crosses should give us useful information on where to look for hybrid vigour.

INTROGRESSION OF WILD SORGHUM CHARACTERS INTO CULTIVATED SORGHUMS

The introgression study reported in last year's Annual Report was continued by another Makerere student, Mr. B. N. Majisu. A large range of types was grown out but a smaller number of characters measured. On the basis of last year's work it proved possible to select the most promising characters for study. The populations used include F_1 populations between wild and cultivated sorghums produced last year, together with their parents. These gave an artificial comparison with the natural situation.

Confirmation was obtained that wild and cultivated sorghums are hybridising and introgressing in East Africa. Furthermore it was shown that in many respects the sorghums of Indian origin which we have in our collection form a group distinct from the African sorghums, as also do the Kaoliangs. Indications were found that the latter group may be being influenced by the wild *Sorghum propinquum* in much the same way as the African sorghums are being influenced by *S. verticilliflorum*.

The artificially produced hybrids have been selfed and back-crossed to both parents, and the hybrids themselves remade. In this way we expect to build up a set of introgressing hybrid populations artificially to act as a control comparison with the natural situation.

PLANT PATHOLOGY

RESISTANCE IN MAIZE TO THE VIRUS OF STREAK DISEASE

H. H. Storey and A. K. Howland

The aims of our studies, and the methods used, have been explained in earlier Annual Reports. Up to 1960 we had obtained a considerable bulk of data but from these no clear genetic hypothesis had emerged. During the past year, however, an analysis of the data has been started on different lines and as a consequence some order is beginning to appear in the previously confused picture.

To confirm the new hypothesis, if indeed it is true, it was necessary to undertake a further series of tests in our glasshouses. During 1961 these were fitted into the pathology programme in which other investigations, described elsewhere, have received greater attention than previously.

It now appears that a comparatively simple explanation of our results may emerge, provided certain assumptions are made. Before confidence can be placed in this explanation, however, the assumptions must be subjected to experimental tests. It is to this facet of the problem that our work is now directed.

During 1962 we hope to arrange some co-operative field trials, which will test our hypothesis and indicate the practicability of breeding useful resistant lines. It is worth while bringing this project to completion, even though practical difficulties in applying the conclusions to general maize improvement, including the shortage of plant breeders available to collaborate in suitable localities, may defer full use for the time being.

THE TROPICAL RUST DISEASE OF MAIZE CAUSED BY *Puccinia polysora* UNDERW.

H. H. Storey and A. K. Howland

Work on this problem at E.A.A.F.R.O. had been discontinued in 1958 (*Record of Research,* 1958, p. 58 and earlier years). It had been established that two physiologic races of the rust fungus existed in East Africa designated E.A.1 and E.A.2; the former was thought to be the only race prevalent in the field, while E.A.2 had appeared in the Muguga glasshouses but had been recognized nowhere else. This work had shown that two dominant major genes obtained from

Central American maizes might independently control resistance: one, Rpp_1, afforded practical immunity from race E.A.1 but was quite ineffective against E.A.2, while the second, Rpp_2, gave effective resistance against both races.

Plant breeders in the three mainland territories had meanwhile transferred the resistance genes to several local maize types by the straightforward method of back-crossing and selection effective in single-gene inheritance, and stocks of resistant maizes had been built up.

Meanwhile, at all testing sites no breakdowns in the resistance of maizes carrying gene Rpp_1 had been reported; and this fortunate situation has continued until 1961. As recently as April, 1960, a collection of rust from the Kenya Coast had proved, in our glasshouse tests, to be race E.A.1 only.

We have been well aware that, by analogy with other plant rusts, the stability of the prevalent race might not continue indefinitely; and we have repeatedly stressed the danger that new races might appear. In the middle of 1961 the multiplication plots of the Kenya Department of Agriculture in the Shimba Hills, near Mombasa, were heavily attacked by rust. The plants in these plots were derived from resistant lines bred at the Kenya Coast, and they had maintained their resistance for several years.

E.A.A.F.R.O. received samples of the rust from Shimba, and glasshouse tests proved that it was fully virulent to our differential test maize lines, carrying the two genes Rpp_1 and Rpp_2. Evidently a new race of *P. polysora* had appeared, and to it the two genes afforded no resistance. We have designated it E.A.3.

During the latter half of 1961 we undertook a preliminary search for resistance to E.A.3. Maize varieties tested by inoculation in the glasshouses included stocks of various origins from the maize breeders' programmes at Kitale and Katumani, Kenya. Among these we found no evidence of any useful resistance.

In a collection of 17 varieties from Central America, supplied by Mr. Dowker from Katumani, a low level of resistance was found in some plants of four varieties. Similar low resistance appeared in one variety imported to Muguga from Mexico. Although this kind of resistance is very poor compared with that studied in our early work with races E.A.1 and 2, it is the best we have found so far against E.A.3; and plants showing the best reactions are being grown on at Muguga.

The next stage, now in progress, is to test against E.A.3 the survivors of some 200 varieties introduced from Central America in 1952/53.

It remains to be decided later in 1962, in the light of all preliminary results, whether E.A.A.F.R.O. should embark on a full-scale genetical study of resistance to race E.A.3.

RUST DISEASE OF BEANS (*Phaseolus vulgaris L.*)

H. H. Storey and A. K. Howland

We reported in 1960 that our main project was to assist in the search for white haricot beans resistant to rust (*Uromyces phaseoli*) that were also of a type suitable for the canning trade. Several varieties sent to us by Mr. Macartney from Tengeru proved to be resistant to both the races of rust that we had so far identified. This year a third race of rust has been found to which most of the above-mentioned varieties also proved resistant.

We have therefore devoted most of our time to making an East African survey of rust incidence and race categories. This has been made possible by the co-operation of the Departments of Agriculture of Kenya, Uganda and Tanganyika, whose field officers have sent in, so far, some 80 samples of rust found in the field. The number of known rust races is still confined to three, but these are found in all three territories and often together in the same area. Our records are still extremely few, and very widely scattered, and we are hoping to receive more samples during the future growing seasons.

THE STEM-PITTING CONDITION IN COFFEE

F. M. L. Sheffield

The symptoms of this condition bear a striking resemblance to those of some virus diseases in *Citrus* spp. and I was asked to determine whether or not the coffee condition is due to virus infection. All available evidence now indicates that no pathogen is involved.

The possibility of the condition being due to a visible pathogen such as a fungus, a bacterium or a nematode has already been eliminated and it is now possible to summarize the results of the more important experiments listed in the Annual Report for 1960 to test the virus hypothesis:—

1. Approach grafts were made in the glasshouse between healthy seedlings and rooted cuttings from affected trees at Lyamungu. When the union was complete the cutting was

severed below the graft. Twenty such grafted seedlings, an equal number of healthy seedlings and the original rooted cuttings were retained in the glasshouse for about a year and in November, 1959, were planted out at the Irrigation Research Centre at Mwea/Tebere. Two years later all the seedlings, both grafted and ungrafted, showed the stem-pitting condition not only at the base of the trunk but the whole way up the suckers. A few of the cuttings used were apical and these were indistinguishable from the seedlings. The majority were, however, lateral and had attained a height of only about 4 ft. but had produced a dense canopy of about 6 ft. diameter. None of these showed stem-pitting.

2. Twenty scions from affected trees at Lyamungu were top-cleft grafted to healthy seedlings. Ten controls were grafted with scions from healthy seedlings and ten were untouched. They were kept for six months in the glasshouse and were then planted out at Mwea/Tebere. After two years, all 40 seedlings showed the condition at the base and high on the suckers.

3. This experiment was exactly as 2, except that the scions came from affected trees at the Scott Agricultural Laboratories and the trees were planted out in the Horticultural Nursery at Muguga. It was done six months before experiment 2. Trees from both experiments were examined about the same time. Those at Muguga were less well grown but none showed any symptoms of the condition.

4. Bench grafts were made of ten roots from affected trees at the Scott Laboratories to healthy seedlings. From control seedlings a root was removed by a slanting cut and was replaced. Good unions were obtained in four plants from each series. When examined after 18 months, no signs of stem-pitting were found.

5. (*a*) Ten healthy scions were top-cleft grafted to an affected tree at the Scott Laboratories together with ten scions from affected trees as controls. (By analogy with viruses of *Citrus* spp., stem-pitting should occur immediately above the graft.)

(*b*) Similar grafts were made in the glasshouse to rooted cuttings from affected trees. These were later planted out at Mwea/Tebere.

These two experiments were invalidated when it was found that xylem tissue typical of the stem-pitting condition is produced near the union when a scion of a healthy seedling is grafted to another healthy seedling. However, some of the cuttings used in (*b*)

were apical and others were lateral. After growing for two years at Mwea, the former showed stem-pitting, but the latter, all of which had produced a dense canopy, did not, although they had originally come from affected trees.

Plants from certain other experiments were planted out at Muguga and at Mwea/Tebere. Of a total of 140 at Muguga, not one developed the stem-pitting condition, whilst at Mwea, of a total of 136 plants, only those grown from lateral cuttings from affected trees remained free from it. None has, however, shown swelling of the trunk, but most affected trees have suckers that are abnormal all the way up.

If the condition were due to virus infection, the symptoms should have appeared only in plants grafted with scions from affected trees. At the beginning of each experiment, each plant was paired with its control for similarity of variety, size, etc. There was a possibility that the appropriate insect vector was present at Mwea, that certain plants had been infected by grafting and the controls were all immediately infected by insects when planted out. To test this hypothesis ten pairs of trees were taken up and their trunks were sectioned. The onset of stem-pitting seemed in all cases to be about the time of planting out. Further negative evidence of the virus hypothesis is provided by the failure of the rooted cuttings from affected trees to develop the condition even in a situation where it is prevalent, and by the failure of even the plants grafted with affected scions to show symptoms when grown at Muguga.

There is still no evidence that stem-pitting confined to the base of the trunk does any harm to the tree unless, as occasionally occurs when the trees are improperly grown, it is followed by fungal invasion. However, stem-pitting in very young seedlings as seen at Lyamungu, and high on the suckers as at Mwea and Lyamungu, may do harm as the xylem cylinder is mechanically weakened and therefore liable to break in a high wind or if a heavy crop is carried.

The type of xylem characteristic of stem-pitting does occur quite normally in coffee trees at the nodes. It is also produced when a tree is capped, or at a graft or as a reaction to accidental wounding such as damage by hail or by a hoe. Attempts to produce it experimentally have so far resulted in only very few small pockets of abnormal tissue or in excessive production causing death.

It seems likely that the condition may arise in the field from more than a single cause, but at least one of these should be found if the environmental differences between Muguga and Mwea/Tebere are explored.

MISCELLANEOUS WORK

F. M. L. Sheffield and H. Y. Kulkarni

A start has been made on investigations into virus diseases of legumes, but an appeal for specimens has so far brought very little response.

A study of an abnormal condition of Napier grass occurring in Uganda has also begun.

H. Y. Kulkarni has prepared bibliographies concerning smut and ratoon-stunting diseases of sugar cane.

EXCLUSION OF FOREIGN DISEASES OF PLANTS

H. H. Storey and F. M. L. Sheffield

Work on importation control continues to fall heavily on members of the Pathology Department. H. H. Storey, who acts as Chairman of the East African Standing Technical Committee on Plant Import and Export, has had to deal with a number of controversial matters during the year. F. M. L. Sheffield, who is a member of this Committee, has acted as Secretary during the absence on long leave of P. J. Dickinson. She also attended the Sixth Annual Meeting of the Inter-African Phytosanitary Commission, held at Ibadan, as the East African representative and as leader of the United Kingdom delegation.

We continue to accept responsibility for the scientific supervision of the East African Plant Quarantine Station and, since the absence of the Horticulturist, F. M. L. Sheffield has undertaken the general management, with W. B. May supervising the horticultural side of the work.

We are both members of the Standing Committee on Sugar Cane Diseases of the International Society of Sugar Cane Technologists. H. H. Storey has contributed to a book published by this body and F. M. L. Sheffield has assisted in the preparation of a World List of Diseases.

PLANT NEMATOLOGY

A. G. Whitehead, M. A. Ledger and L. Kariuki

The Nematologist trained two assistants from the Scott Laboratories, Nairobi, an Assistant Agricultural Officer and Agricultural Assistant (Research) from Kawanda Research Station, Uganda, in field and laboratory techniques used in the study of root-knot nematodes (*Meloidogyne* spp.). He also paid advisory visits to Tanganyika and Uganda and planned a tobacco root-knot research programme for Uganda.

TAXONOMY OF *Meloidogyne goeldi* ("ROOT-KNOT" NEMATODES)

Root-knot nematodes are thought to constitute, economically, the most important plant-parasitic nematode genus in East Africa. The taxonomy of the genus is at present in a very unsatisfactory state and a critical analysis o f the group is now in progress to assist the implementation of biological methods of control in the field. Work is well advanced along the following lines of study:—

(1) Study of type material of some *Meloidogyne* spp.

(2) Collection, maintenance and study of topotypes of *Meloidogyne* spp.

(3) Study of local variation in some *Meloidogyne* spp.

(4) Clonal-host reaction technique for differentiation of *Meloidogyne* spp.

(5) Mitotic metaphase chromosome counts.

(6) Morphological analysis of posterior cuticular patterns of East African root-knot nematodes.

DISTRIBUTION OF *Meloidogyne* SPP. IN HEAVILY CULTIVATED AREAS OF EAST AFRICA

Intensive root-knot nematode surveys have been carried out in 12 50-square-mile areas selected for heavy cultivation over a wide range of altitudes, rainfall distributions and soils in Kenya, Uganda and Tanganyika, but each containing a considerable area of intensive African cultivation. In all surveys but one (Kabale region of Kigezi District) the range of test crops was widely attacked by *Meloidogyne* spp. The comparative rarity and lightness of attacks in the Kabale survey is thought to be correlated with the high, non-friable clay content of the soils.

The objects of these surveys are—

(*a*) to assess the relative severities of attack of the same range of host plants over a wide range of environments;

(*b*) to supplement distributional data for *Meloidogyne* spp. already obtained and to map the potential distribution of species already in East Africa;

(*c*) to provide a basis for the implementation of crop rotational control methods; and

(*d*) to determine the morphological range of posterior cuticular patterns of each species over a wide area.

Major faunal differences have been found between the areas surveyed, but a considerable amount of identification work has yet to be carried out.

Fig. 1.—Location of the twelve survey areas

HOST-PARASITE RELATIONSHIPS OF *Meloidogyne* SPP.

The specificity of some aspects of the interaction between the host and populations of root-knot nematodes is being studied, partly as an adjunct to the taxonomic studies mentioned above and partly to determine the degree of biological variability possessed by root-knot populations of known origins.

The host-parasite relationships being investigated are—

(*a*) the effect of seedling hosts upon the host preferences of single root-knot populations;

(*b*) the specificity of the gall, morphologically and histologically, resulting from given host-parasite interactions; and

(*c*) the sex-ratio.

NEMATODE PROBLEMS OF EAST AFRICAN CROPS AND METHODS OF CONTROL

Virginia Tobacco

In a time of planting—fertilizer rate—soil fumigation trial laid down by Mr. Barry Walker, Agricultural Officer (Tobacco) on Seatondale Tobacco Experimental Farm, Iringa, Tanganyika, 1 : 4 dichloropropane-dichloropropene mixture (Shell "DD") at 6 cc. per planting hole increased the tobacco leaf yield, over a number of plots on moderately infested land, by 50 per cent. This trial is being repeated this season and further demonstration plots are being laid down at outstations.

Failure of tobacco seedbed fumigation in the West Nile District of Uganda has been investigated and the Uganda Department of Agriculture is to carry out experiments designed to discover the cause and determine the best methods of fumigation for tobacco nurseries.

In extensive pot trials at Muguga to discover useful root-knot resistance in cultivars suitable for Iringa District, near immunity was detected in Enyanza, Dobbs and Msumbiji sorghums, Natal common groundnut, one variety of Rhodes grass and Mexican marigold. High levels of resistance to most lines of *Meloidogyne javanica* and *M. incognita* were also discovered in Columbus grass and Katumbili maize. Testing will continue to the point where general recommendations of crop rotations for Iringa District tobacco farms can be made.

Arabica Coffee

The Nematologist has collaborated with the staff of the Coffee Research Station, Lyamungu, Tanganyika, in further studies on the root-knot nematodes of Kilimanjaro Coffee.

Six replicated Nemagon fumigation trials have been laid down, four at Lyamungu and two at outstations, aimed at determining the probable influence of root-knot attack—very common on Kilimanjaro and in the Pare and Usambara Mountains—on the mature coffee tree and whether such fumigation is effective and economic. In four out of five trials on sites chosen for heavy root-knot attack, 7.5 gallons/acre reduced infestation rate considerably, i.e. from about 90 per cent to 15 per cent, but on the fifth trial the fumigation had no effect. On one trial even 2.5 gallons/acre was effective. The effect of nematode control on the growth and vigour of coffee trees and on their yield is being recorded in these experiments.

A seedling pathogenicity trial has been set up to determine the effect of heavy root-knot attack upon the growth of young coffee plants and a clonal pathogenicity trial is being set up with the assistance of Mr. L. M. Fernie, Horticulturist.

Root-knot nematode attacks are common on wild *Rubiaceae* in the primary forest on Kilimanjaro.

Banana

Little progress in the study of the inter-relationship of nematode attacks and Fusarium-wilt disease of bananas in South-West Uganda can be reported, owing to the difficulty that has arisen in the production of young banana plants by the "peeper-rooting" technique when applied to the three Uganda varieties intended for a pot trial.

Tomato Investigation

Seed of five varieties of tomato, found to possess a measure of resistance to *Meloidogyne javanica* in Australia, were imported by the Kenya Department of Agriculture. Advice was given on setting up an experiment to test the resistance of these varieties to the common species of *Meloidogyne* in tomato-growing areas in Kenya. The experiment, set up by Mr. P. H. Fox at the Scott Agricultural Laboratories, was a test of the resistance of these five varieties to an inoculum made up of several populations of *Meloidogyne* found on plants in Kikuyu Division, Kiambu District, known to contain amongst them *M. javanica*.

RESULTS

Variety	Treatment	No. of Plants Tested	Mean Index*	Index Range
H/F	Inoculated	9	2·75	0–5
	Control	9	0·00	—
M 25–B	Inoculated	9	2·77	0–5
	Control	9	0·00	—
Merbein Early ..	Inoculated	9	0·11	0–1
	Control	9	0·00	—
Merbein Canner ..	Inoculated	9	1·27	0–4
	Control	9	0·00	—
Merbein Midseason	Inoculated	9	3·62	3–4
	Control	9	0·00	—

*Root-knot indices:—

0 = no galling, no reproduction;
1 = very light galling;
2 = light galling;
3 = moderately heavy galling;
4 = heavy galling;
5 = severe galling.

The infestations produced by inoculation of these varieties all proved to be of *M. javanica.*

A useful measure of resistance to *M. javanica* appeared only with Merbein Early and this is subject to further testing.

RESISTANCE OF *Tagetes minuta* L. TO SOME SPECIES OF *Meloidogyne*

In pot tests at Muguga, *Tagetes minuta* L. (Mexican marigold) was found to possess a very high degree of resistance to *M. javanica* (selection from tomato roots, Limuru, Kenya), the commonest species of *Meloidogyne* in East Africa.

When *Tagetes minuta* L. was grown for three months in sterile soil, inoculated with *M. javanica,* it was found that a subsequent planting of the susceptible Moneymaker tomato variety remained free from root-knot attack. The rapidity with which this control was obtained suggests that Mexican marigold may have a valuable application in the control of the eggs and larvae of *M. javanica,* or at least of those present in the top foot of soil. The action of Mexican marigold on the root-knot population of the soil is not clearly understood and seems worth further attention. Two hypotheses may be advanced to explain it—

(*a*) the herb secretes toxic substance(s) through its roots which kill both eggs and larvae; or

(*b*) the herb secretes substances through its roots which are highly attractive to the larvae and also stimulate complete hatching of all eggs in a few weeks. The larvae are killed at the surface of or within the roots.

When Moneymaker tomato plants and Mexican marigold were sown together in the same pots of sterile soil, inoculated with *M. javanica,* the tomatoes were as heavily attacked as those in similar pots without the Mexican marigold. If hypothesis (*a*) is correct such a result would seem to suggest that the toxic substance(s) are produced late in the life of the plant so that early tomato infections can occur and any build-up of root-knot infection on the tomato plants during the period of toxic activity must be due to migration of infective larvae *within* the root tissues.

The very high degree of control of *M. javanica* by Mexican marigold prompted the incorporation of the weed in the Iringa crops root-knot susceptibility tests. The results are extremely encouraging since not only did the Mexican marigold maintain its complete resistance to *M. javanica* lines but in almost every case it showed similar resistance to *M. incognita* (both *incognita* and *acrita* type) lines as well.

Tylenchulus semi-penetrans ("CITRUS-EELWORM")

Tylenchulus semi-penetrans has been confirmed for the first time in East Africa on citrus, in the Coast Province of Kenya. This is a pest of world-wide distribution in citrus-growing countries but hitherto was unknown in East Africa. A report of the pest by Trought in Uganda was followed up but the nematode could not be found.

QUARANTINE INTERCEPTIONS

During the year three important plant-parasitic nematode species have been intercepted at the East Africa Plant Quarantine Station—*Aphelenchoides besseyi,* said to cause "white tip" disease, on two rice varieties of Indonesian origin, *Meloidogyne* sp. *javanica* and *Rotylenchus erythrinae,* both on one species of ornamental among a collection of United Kingdom origin.

ANIMAL HUSBANDRY

BEEF CATTLE UNIT

W. J. A. Payne, H. G. Livingston, H. P. Ledger and Nelson Mwangi

The co-operative trial with the Department of Veterinary Services, Tanganyika, on a study of the water requirements and productivity of indigenous cattle when subject to the stress of infrequent watering and long daily treks continues. It will be completed during 1962. Interim results were reported at the Eighth International Congress of Animal Production in June, 1961, at Hamburg, West Germany. These suggest that feed intake is more decisive than water intake in its effect on liveweight gain. They also showed that the capacity of the deprived animals when allowed to drink was surprisingly large. At the end of the dry season they were drinking on average a volume of water equivalent to 17 per cent of their "full" body weight, individuals drinking as much as 27 per cent. Results of the blood analysis suggested that dehydration had not progressed to the stage where it was affecting to any degree the normal physiological function of the animal.

The study on the relative efficiency of Boran and Shorthorn Zebu cattle in converting feed into beef continues. The animals in the experiment are a random selection of the progeny from randomly purchased Boran and Shorthorn Zebu cattle. Approximately half the total number of groups required have been assembled. Information on the weaning weights of the first six groups is given in Table 1. Neither the Boran nor Shorthorn Zebu calves appear to have benefited from high plane nutrition, and there is little difference in weight between the two breeds. This is surprising as the difference between the planes of nutrition is wide. The low plane animals are run in "Themeda-acacia" bush country and the period under review has coincided with the long drought period that has been experienced in this country. The high plane calves receive a 12 per cent crude protein concentrate ration *ad lib*, as do their dams, and they are grazed out on the best pastures at Muguga during the day. The dams and calves also receive supplementary hay, green feed and minerals. It is almost impossible to distinguish morphologically between the calves of the two breeds.

Studies on ruminant nutrition with special reference to the nutrition of cattle in semi-arid areas have continued. These have mainly been concerned with our hypothesis that indigenous cattle possess a nitrogen-sparing mechanism. In considering why indigenous ruminants in East Africa apparently do well on feeds of

very low nutritional value, the work of Schmidt-Nielsen with camels came to our notice. When a growing camel was maintained on a low nitrogen intake the amount of nitrogen excreted in the form of ammonia, urea and creatinine decreased to 2-3 grammes per day and this was caused by a drop in urea excretion from 13 grammes to 0.2 to 0.5 grammes per day. Even when urea infusions were given, all the urea given was retained by the animal and did not increase concentrations in the urine. Schmidt-Nielsen concluded that under conditions of metabolic stress, that is low protein and growth, the camel is apparently able to reprocess "waste urea" into new protein by some form of physiological blocking mechanism preventing the normal excretion of urea in the urine.

TABLE 1—BORAN-SHORTHORN ZEBU COMPARISON AT HIGH AND LOW PLANE NUTRITION
(6 groups)

	HIGH PLANE		LOW PLANE	
	Boran	Shorthorn Zebu	Boran	Shorthorn Zebu
Birthweight (lb.)	51·8	41·7	55·2	41·2
Weaning at 36 weeks (lb.) ..	343	304	345	291

Until very recently little work has been done on the role of saliva and nitrogen metabolism. McDonald provides information on this aspect and was the first to show that salivary urea is of considerable significance when the daily volume of saliva is considered.

Recently Somers in Australia has established that Merino sheep have the ability to block urea excretion and recycle it for re-use in the rumen when under protein stress.

When one considers that African ruminants have evolved over the years on grazings very low in protein it would not be unreasonable to assume that they too have had to develop the same nitrogen sparing mechanism that has been established in the camel and Merino sheep. This may be especially true for wild ruminants.

We believe that this "urea sparing effect", if operative in indigenous ruminants, may be a function of water economy. Urea is normally excreted in the urine continuously and under conditions of water deprivation this need to excrete urea could further embarrass the animal in the water economy sense.

This study is of great practical importance at present due to the awakening interest in the use of synthetic feed urea for range lands. One would suspect, in the light of the foregoing discussion,

that the feeding of more urea to animals which may already have high gut contents of urea could be fraught with danger as urea poisoning is quite common when the urea level exceeds one-third of the protein equivalent of the ration.

In these studies the initial phase has been the collection of 24-hour urine samples which are chemically analysed for urea-nitrogen, total nitrogen and ammonia-nitrogen in association with an overall nitrogen balance assessment. Very many technical difficulties associated with the collection of an uncontaminated 24-hour sample of urine have had to be overcome. For example, one urine collection harness, which collected the urine very efficiently, had to be withdrawn from use as the ammonia levels of the collected urine rose very rapidly, invalidating the results. It was found necessary to collect the fresh urine into a preservative (sulphuric acid) to obtain representative samples. The practical observations and results from this work casts doubt on the validity of many previous trials, such as nitrogen balance experiments, where adequate precautions against the rapid evolution of ammonia, due to the collection technique, have not been taken.

Despite all the delays and setbacks due to the difficulties outlined above, several ten-day experimental periods have been conducted. The original 24-hour collection periods had to be discontinued owing to very significant daily variations in the excretion patterns of the nitrogenous components. The ten-day total collection periods involves a considerable amount of chemical analysis and the assistance of Mr. M. T. Friend in this connexion is gratefully acknowledged. In each ten-day run a complete nitrogen balance is undertaken and the urine is further analysed for urea-nitrogen and ammonia-nitrogen by the Conway microdiffusion method. A control run of the experiment involved two Ayrshire-grade identical twins and two Zebu identical twins. All were on a ration containing approximately 12 per cent crude protein. No real differences in nitrogen excretion emerged, but it was noted that the Zebu twins did not seem as well adapted to the 12 per cent protein ration as the Ayrshire grades. In a subsequent run of ten days, one Ayrshire grade and one Zebu were fed a ration of slightly lower protein content of about 8 per cent. From the onset of this trial the Zebu on the lower protein ration excreted approximately 50 per cent less urea-nitrogen than its co-twin on the 12 per cent protein ration. The lower protein Ayrshire also excreted less urea-nitrogen than its co-twin but not to such a degree as the low protein Zebu. The interesting point which emerges from this work is that while on the lower protein intake the Zebu and the Ayrshire both excreted less total nitrogen and less urea, the ratio of urea-nitrogen to endogenous nitrogen remained constant. When one realizes that the Zebu

excreted much less urea and total nitrogen than its Ayshire experimental mate under the same experimental conditions, it would appear that endogenous nitrogen, that is non-urea-nitrogen components, such as creatine and hippuric acid, are also being "spared". One would imagine that under the same conditions the non-urea components of the urine would remain constant between the Ayrshire and the Zebu even although the urea excretion pattern was different. (This finding leads to interesting speculations.) It must, however, be stressed that these are interim findings and much work is required before definite conclusions can be drawn. The next phase of this experiment is to reduce the protein content of the ration of the "stressed" animals still further to see if the sparing mechanism, so evident with a drop in protein content of only 4 per cent, is further exaggerated between the species.

The draft memorandum on liveweight gain trials mentioned in last year's Report has been greatly expanded and was the subject for discussion at a conference in Uganda in October. This new memorandum is entitled *Pasture Evaluation Techniques for Research Workers in East Africa,* and it has had a very favourable reception.

MEAT UNIT

H. P. Ledger and W. N. O. Gichuru

An addition to the routine analyses of Boran Zebu steers which continued throughout the year was the analyses of a small number of Shorthorn Zebu steers for the officer in charge of the Serere Experimental Station of the Uganda Department of Agriculture. At the request of the Uganda Veterinary Department, Mr. Ledger also attended a carcass analysis of some Shorthorn Zebu steers being carried out by that Department at Entebbe.

Further work on the use of sample joints, this time for use with fat-tailed sheep carcasses, has been carried out during the year in co-operation with Dr. Hutchinson and Mr. Bell of the Tanganyika Veterinary Department. This work is currently being analysed and preliminary findings indicate that sample joint techniques also apply in the case of fat-tail sheep.

Further carcass analyses of some species of ruminant game animals were carried out during the year and have yielded some most interesting results. In general terms it appears that game animals have a high killing-out percentage, in the upper 50's and lower 60's, but that at these percentages the fat content of the carcass is extremely low, rarely rising above 2 per cent of the carcass. The total digestive tract expressed as percentage of the liveweight is of a similar order to that of cattle with the same killing-out

percentage. It appears that the high killing-out percentage results from the ability of the animal to carry a higher percentage of muscular tissue for a given killing-out percentage than does the domesticated animal. There is evidence that the body composition of herbivorous species may be related to physiological factors concerned with their ability to withstand water deprivation.

Observations on game animals have made it necessary to carry out, for comparative purposes, carcass studies on entire male Borans and females and also it has been necessary to extend the carcass analyses to include records of the offal of the domesticated stock. Such reorganization has necessarily slowed down the number of animals per annum that can be analysed but has materially increased the value of the information that can be obtained from each.

The initial programme of providing a datum line from the information obtained from unselected Boran steers reared on grass has been completed and papers are being prepared for publication under the general heading of *The Carcass Composition of East African Ruminants* for submission to appropriate scientific journals.

MUGUGA SOUTH FARM

A. F. Dent and Mayda Kapitapa

Buildings

Since the last Annual Report a new machinery shed has been built and is almost completed except for the stoning of the floor. The post-farrowing house has been re-roofed and the electric cable has been renewed and brought up to standard.

A further 16 individual feeding pens in the main fattening house have been rebuilt to the new design. The old horse boxes have been converted into a metabolic unit for Dr. Livingston's nutritional experiments and four boxes have been divided to make boar pens. A stone lean-to building has been erected as a sick animal isolation box.

Pastures

Owing to the failure of the "long" rains only 18 acres were planted to Star grass during the year and 158 bales of hay made. The short rains being exceptionally heavy this year, 60 acres have been closed for hay.

Crops

Oats.—Owing to the failure of the "long" rains very little straw was available. About 15-20 acres have been planted during the "short" rains but not yet harvested. Owing to the country-wide scarcity of oat seed only a very limited quantity of seed could be obtained.

Sweet Potatoes.—Twenty-four and a half acres were planted to sweet potatoes for grazing during the dry period by the E.A.V.R.O. herd; this area will be planted to Star grass in the "long" rains.

Panicum maximum var. *trichoglume.*—The "misses" have been replanted on the nine acres of the Physics Division experiment, but the germination is still very disappointing.

Livestock

Details of the numbers of livestock, with the exception of the twin sets, on Muguga South Farm and Kedong Ranch at 30th September are given in Table 2.

Beef Cattle.—No purchases have been made during the year. Twenty-two head of cattle were lost due to stock thefts.

Identical Twin Herd.—Sets of twin calves have been collected during the year at a satisfactory rate. Details are given in Table 3. There has been no serious disease in the herd during the year.

Sheep.—The foundation herd of Wiltshire Horn sheep were stolen and are not being replaced.

Pigs.—Two large white boars have been purchased during the year; unfortunately one broke its leg and had to be killed.

The herd is still well below the target figure for total number of breeding stock. No major outbreak of disease has occurred during the year.

Labour

The labour force has remained constant during the year and no labour disputes have occurred.

TABLE 2—TOTAL NUMBER OF LIVESTOCK AT MUGUGA SOUTH FARM AND KEDONG RANCH—30-11-61

Cattle

(excluding twins)

Total	Cows and Heifers 2 yrs. and over	Calves to 9 mths.	Yearlings	Bulls and Steers
188	83	44	59	2

Pigs
(as at 30–11–61)

Total	Sows and Gilts	Weaners	Fatteners	Boars
217	37	49	124	7

TABLE 3—TWIN SETS AT MUGUGA SOUTH FARM

GRADE SETS		PART ZEBU SETS		ZEBU*		Total
Male	Female	Male	Female	Male	Female	
15	13	3	6	13	9	59

*Ten sets in Tanganyika

KEDONG RANCH

I. Patchett and J. Session

Weather

On 1st May, 1961, the Meteorological Station came into operation. The first nine months of 1961 were hot and dry and until the "short" rains only 4.42 in. of rain were recorded. 17.81 in. were recorded in November.

Buildings

Since 1st May, 1961, a stock yard has been built together with two new labour houses, one night boma, two water troughs, an engine shed for the spray race and other minor items.

Grazings

Grazing has been worked on a four-block rotation system but the extremely dry and arid conditions prevailing in the first nine months of the year meant that the grazing regime could not be followed properly. Block 4 should have been burnt but owing to the failure of the "long" rains and a shortage of grazing burning has been put off until 1962.

At no time was the Kedong Ranch ever completely grazed down, at least not on the standards set by some of the neighbouring farmers. Block 4, although mostly standing hay, was still capable of supporting all our stock, i.e. nearly 140 head. Army worm appeared in the middle of the year but not in sufficient numbers to do any harm.

Since the heavy rains in November the picture has altered completely. Many legumes have appeared together with patches of Star grass and Rhodes grass and large stands of Red Oat grass.

Trees

Very little has been done in 1961 over tree planting owing to the lack of rain. The plane tree, *Platasanus occidentale,* was planted in November but it is as yet too early to say whether it will survive.

Livestock

No losses from disease were recorded during the year—the only death being that of a small calf which died from malnutrition when the dam failed to feed it properly.

Routine prophylactic inoculations and spraying were carried out, and general health has been very good. As might be expected, some loss of condition occurred after the heavy rains in November, but recovery was rapid.

Two stock thefts were made during the year by Masai, one in June when nine head were stolen and one in October when four head were stolen. The cattle stolen in June were recovered by a police tracker party together with some of our own herders, but owing to Veterinary Department quarantine restrictions which forbid re-export of stock from Masai land these cattle were sold at a local auction. The cattle stolen in October were not recovered, but compensation has been claimed as the cattle were tracked well within the Masai boundary. A Police Post has now been opened on the Ranch.

The heavy rains have made it impossible to obtain four replacement Boran bulls from ALMO at Isiolo.

It was also hoped to obtain four Shorthorn Zebu-type bulls from Baringo. Here again the heavy rains made this impossible.

FORESTRY

SILVICULTURE RESEARCH

A. L. Griffith, P. Howland, Ernest Warari, Evanson Ndungu and Amos Wanene

This Division has for the last nine years been following a long-range programme of research laid down for us by the East African Advisory Council in 1952. This programme was intended to last at least ten years and will be reconsidered and revised in 1962, after the meeting of the Eighth British Commonwealth Forestry Conference which will be held here in East Africa.

In November we held the Ninth Forestry Course at Muguga. It was attended by 19 delegates from the East African territories, including seven African Foresters and one member of the teaching profession. In all we have now had 150 Assistant Conservators and Foresters, etc., on the courses. On a number of occasions throughout the year parties of Boy Scouts have camped at E.A.A.F.R.O. for a weekend and were given instructions in tree pruning and thinning.

The year 1961 has been a year with a remarkable rainfall pattern. The first nine months of the year produced only some 60 per cent of their normal amount but the total rainfall of the year exceeded the normal by some 55 per cent. It was also the highest total rainfall recorded here since 1951. The "long" rains of March, April and May were, like those of 1960, poor, and produced only 71 per cent of their normal amount. Planting was done successfully in the middle of April some two weeks later than last year. This has been our third consecutive year of difficult planting and establishment conditions and, as in the two preceding years, the validity of our methods to ensure that young plants have the best opportunity to survive and make the maximum growth have been conclusively proved.

Our working year is a climatic one and not the calendar year of this report. It starts in the "long" rains season, which is the usual planting time, and finishes the following March. In this respect, therefore, most of the results in this report are based on the measurements and assessments made on the experiments of 1960. This year's results will be recorded in the 1962 report.

The study of root development and mycorrhizal production during the period immediately following planting in the field was continued this year. We were able to observe that the initial root

growth on pine seedlings planted early in the "long" rains, when available soil moisture was low, was slower than those planted later, when available soil moisture was high, but their subsequent rate of development was much faster. We were also able to determine that the "hardening-off" process, normally given to seedlings prior to planting in the field, had no deleterious effect on the time taken for them to produce new roots. This work is described under short-term planting-out problems.

During the year we completed the compilation of the first provisional East African yield tables for the cypresses of the *C. lusitanica* group. The tables will be issued in *E.A.A.F.R.O. For. Tech. Note* No. 11 early in 1962.

The headings of the report that follows are those of the long-range programme.

I. INFORMATION SERVICE

The backbone of this service is the Forest Bureau which now contains 2,038 Specific Ledger Files and 913 General Ledger Files. Information continued to be disseminated by means of lists of highlights of items ledgered, by reply to specific inquiries received and by showing visitors something of our work.

II. STANDARDIZATION OF RESEARCH PROCEDURE

The main item under consideration is a uniform Sample Plot procedure for East Africa. Past and present work in all territories is being reviewed.

III. RESEARCH ON SOFTWOODS

In the following report on seed, nursery problems and seed orchards, Mr. W. B. May (Horticulturist) has collaborated.

A. Seed Problems

Cotyledon Numbers

The long-term experiments planted out in 1954 (E.P.4a) and 1955 (E.P.4b) with *C. lusitanica* of two, three and four cotyledons and in 1954 (E.P.7) with *P. patula* of four to nine cotyledons, *P. caribaea* (now *P. elliottii*) of four to nine cotyledons, *P. radiata* of seven to nine cotyledons and *C. lusitanica* of two to four cotyledons were continued. There are still no significant differences in the performances of the trees under observation.

Size of Seed

The long-term experiment planted out in 1954 (E.P.3a) and 1955 (E.P.3b) with *C. lusitanica* of five different sizes of seed were continued. There are still no significant differences in the performances of the trees under observation.

Canker Incidence

In last year's report we recorded varying degrees of canker (*Monochaetia unicornis*) attack in all the above cypress experiments. No further counts have been made but one will be done early in 1962. All the experiments above will be continued, but the interval between assessments will be extended to five years.

Seed Orchards

Great progress has been made this year in clarifying the overall policy and the probable mechanics of future work. Species priority lists have been drawn up, "plus tree" characters have been clearly defined, the desirable timber-qualities listed and the general mechanics of the operation set out from the initial grafting stage (whether the vegetative material is from a local or foreign source) to the establishment of the actual orchards.

This work may be best described as a "combined operation" as contributions have been made by the Forest Research Co-ordinating Committee, the Specialist Committee on Forest Research, the East African Timber Advisory Board, the East African Plant Quarantine Station Service, the Horticulture Division, E.A.A.F.R.O. and a number of specialist officers not included on the above committees.

B. Nursery Problems

(*Experiments started in April,* 1960, *and concluded in March,* 1961)

Experimental work in the nursery at Muguga continued. No new studies have been started but three of the earlier experiments were repeated. We require many years of repetition to cover the range of the variable climate experienced here. In 11 years our total annual rainfall has ranged from 42 per cent below normal to 55 per cent above normal, with four years giving above normal, six years below normal and only one year of nearly normal rainfall.

Fertilizers

The experiments described in previous years' reports were repeated in 1960 (measured in 1961). The species used was *P. patula*

and it serves as a general control of our minimum fertilizer experiments. We now have nine years' repetition. N.P. and K. were applied in all combinations and at three rates which were: —

Fertilizer rate 0		No fertilizer.
Fertilizer rate 5	N.	Sulphate of ammonia (20 per cent N.) 540 lb. per acre or 8 gm. per box.
	P.	Double superphosphate of lime (39 per cent soluble P_2O_5) 540 lb. per acre or 8 gm. per box.
	K.	Sulphate of potash (52 per cent K_2O) 270 lb. per acre or 4 gm. per box.
Fertilizer rate 10		Twice the above quantities.

These rates are called "5" and "10" as they are 5 and 10 times the rates which are normally used in agriculture in the United Kingdom. These experiments again confirmed previous years' indications giving us nine consecutive years of consistent results. These results have been set out in the 1958 and 1959 reports.

Minimum Fertilizer Requirements

These experiments were continued in 1960. The soil mixtures used were (*a*) Muguga standard mixture (without basic N.P.K.) and (*b*) Muguga standard mixture (without basic N.P.K. and without horse manure). Two species were used (*P. patula* and *P. radiata*), to which applications of fertilizers of decreasing rates were given. Five rates were used, 0 (no fertilizer), "5" and $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ of rate "5". There was a significant response to the fertilizer of from 10 to 50 per cent in height growth according to the rate used. These responses confirm previous years' indications that it is probable that rate "5" fertilizer application is the most economical and beneficial rate to use under our conditions. In addition we noted a possible interaction between the horse manure and the two highest "rates" of fertilizer which resulted in a depression of the height growth.

Transplant Spacing in Beds

This study comparing the responses of seedlings when pricked out at 2 in. × 2 in., 3 in. × 3 in. and 4 in. × 4 in. spacing, hence giving each seedling theoretically 24, 54 and 96 cubic inches of soil respectively, was continued this year (1960). The heights of the seedlings at the two wider spacings were 12 and 30 per cent better than those

at 2 in. × 2 in. spacing and also produced sturdier plants. However, to raise the same number of plants as at the 2 in. × 2 in. spacing would, for the wider spacings, mean increasing the transplant bed area by $2\frac{1}{4}$ and 4 times respectively and hence would considerably increase the costs.

C. Short-term Planting-out Problems

We have now completed 135 experiments comparing different establishment techniques since 1952. The first five years' results were summarized and presented to the Seventh Commonwealth Forestry Conference in Australia and also reported in our 1958 report. A further summary of ten years' work will be presented to the Eighth Conference which is to be held in East Africa in June-July, 1962.

Different Dates of Planting

We now have eight years' experimental evidence of weekly planting from the middle of March to the end of May each year for *P. patula, P. radiata* and *C. lusitanica.* With all these three species height growth and survival percentage drop markedly with late planting. At each date of planting the depth of soil wetting is measured and from the daily rainfall records the rainfall "build-up" is calculated by deducting the theoretical evaporation for each day. For the past three years we have, with the help of Mr. P. H. Hosegood of the Soil Physics Division, taken direct soil moisture measurements as a check against these theoretical rainfall "build-up" figures and have found that they are reliable estimates of the actual soil moisture conditions. This year, the differences in mean height growth between early and late planting for *C. lusitanica* and *P. patula* were some 20 per cent and 37 per cent respectively. Differences in survival per cent were however small.

Comparison of Different Depths of Planting

We have now done 14 experiments using *P. patula, P. radiata* and *P. leiophylla* with no contradictory results. The different depths of planting used have been—

(*a*) at the collar;

(*b*) 2 in. above the collar; and

(*c*) 4 in. above the collar.

In six years' work deep planting has caused no deleterious effects, but has caused a stimulation of height growth of from 10 to 30 per cent depending on the climate of the year. This confirms work in other countries.

Comparison of Bare-rooted and Ball-planted Transplant

Seven years' work comparing the two planting methods with *P. patula, P. radiata* and *C. lusitanica* have clearly demonstrated

the marked advantages achieved with using ball-planted plants in all but the most favourable climatic years. The last three years' results for *P. patula* were: —

Year	Long Rains Inches	Survival Percentage	
		Ball Planted	Bare Rooted
1958	20·02	92	88
1959	12·74	85	23
1960	14·49	93	57

Effect of Storage of Bare-rooted Stock

This year we have continued this study with *P. patula*. Stock was lifted, all soil removed from the roots, then wrapped in wet gunny and transported to the planting site. On arrival one set was planted immediately. A second and third set were left in the gunny and kept wet and in the shade for 24 hours and 48 hours respectively before planting. *P. patula* is a more difficult species to handle in this respect but seven years' work have shown that plants can be stored in this way if necessary. *The practice is, however, to be deprecated and planting should be done as soon after lifting as possible.*

Effect of Exposure of Naked Rooted Stock

The experiment this year has produced inconclusive results. Our previous work, however, has clearly shown that even short periods of exposure produce a heavy mortality.

Comparison of the Best Plants with the "Runts" from a Nursery Bed

With this year's experiments done with *P. patula* and *P. radiata* we now have seven years' experimental results. The plants for each treatment were selected from a total of approximately 8,000 plants, the "best" plants being the tallest and sturdiest, and the so-called "runts" being the smallest and weakest. This year's results have confirmed our previous findings in that there was little difference in the survival percentage or in the year's height increment, but at the end of the year the best plants were with both species, some 20 to 30 per cent taller, and were much sturdier than the "runt" plants.

Planting Stock Raised by Different Box and Bed Techniques

Two further experiments were done in which the best bed plants were compared with the best box plants. The species used were *P. patula* and *P. radiata*. Seven years' work have shown that, with our marginal and variable climate, box plants are our best insurance against failure. Plants raised by the cheaper bed method only give satisfactory results in years with a good climate.

Rate of Growth of New Roots and New Mycorrhiza Immediately after Planting

This new study started last year was continued on an enlarged scale in 1961. The methods used were described in last year's report and will not therefore be repeated here. The three species, *P. patula, C. lusitanica* and *E. saligna,* were used again this year and also the two planting methods, where bare-rooted stock was compared with ball-rooted stock for each species. The results this year have confirmed our first indications that new roots are formed as early as the first week after planting (*P. patula* and *C. lusitanica* take between one to two weeks, and *E. saligna* only two to three days), bare-rooted plants tend generally to take longer to produce new roots than ball-planted plants and the subsequent downward rate of growth through the first foot of soil, which varies considerably between species, is of the order of $\frac{1}{4}$ in. per day for pines, $\frac{1}{4}$-$\frac{1}{2}$ in. for cypress and $\frac{1}{2}$-$\frac{3}{4}$ in. for the eucalyptus. Observations on new mycorrhiza production on pine roots were difficult to observe and inconclusive this year owing to the very dry soil conditions pertaining during the period immediately following planting.

A new aspect of "initial root development" was also investigated this year in an experiment run in parallel with the date of planting experiments. At each date of planting additional plants of *P. patula* were planted behind sheets of glass sunk in the ground. The root development of these plants was followed until they had grown downwards beyond the first foot of soil. The results indicate that young *P. patula* plants are very sensitive to soil moisture conditions. Early planting, when soil moisture conditions were low, caused a longer delay in new root production than in later planted plants when soil moisture was high, but subsequent root growth was, however, faster than in plants planted later.

A third experiment was done to observe the effect of the normal "hardening off" process on new root production. The hardening off process consists of an increasing intensity of root pruning combined with a decreasing intensity of watering during the last few weeks the plants are in the nursery. The species used were *P. patula* and *E. saligna.* This year's results indicate that "hardened" stock produced roots as quickly as stock which had not received the special treatment.

Effect of Planting Stock into Pits Prepared Several Weeks before Planting, and into Pits Prepared on the Day of Planting

This is a new study done this year with *P. patula.* One set of plants was planted into pits prepared in the dry season, some six weeks before planting. A second set was planted into pits prepared on the day of planting. Our first results have shown that there is

no difference in the heights at the end of the year, but survival was some 9 per cent less in the latter-type pits. This work will be continued.

Effect of Badly Planted Stock as Compared with Well-planted Stock

This is another new short-term investigation. It had been reported that very young stands of pines, particularly *P. radiata*, were suffering from alleged wind throw. The wind throw, however, was not always in the direction of the wind and appeared often to be due to careless planting. Using *P. radiata* stock we deliberately forced some of the root systems into "L" and "J" shapes at planting time and compared their growth, survival and general behaviour with correctly planted stock. After one year there was little or no difference between the treatments. This work will be continued.

Cover Crops in Young Cypress Plantations

We now have seven years' observations in the experiments (E.P.5). *Prunus salasii* continued to be the most successful cover crop.

Effect of Shamba Crops and Cultivation

The experiment was started in 1955 (E.P.11) in conjunction with the Soil Physics Division to study the effects of *shamba* crops on the height growth and survival percentage of the forest crop of pines. The *shamba* crops were (*a*) maize, (*b*) beans, (*c*) maize and beans. The *shamba* crops had little or no effect on survival percentage but reduced height and diameter growth by some 10 to 15 per cent. No *shamba* crops were possible after the second year but even after seven years their retarding effect was still present. Expressed in terms of volume, this was 15 per cent for maize, 13 per cent for maize and beans, and 8 per cent for beans alone.

D. Long-term Problems

Sample Plots

There has been no work done in the sample plots this year except that of maintenance. Our two oldest plots in *E. saligna* will be due for a full measurement early in 1962.

Effect of Height of Pruning

Two experiments started in 1958 to test the effect on the height and diameter growth of *Pinus radiata* (E.P.17) and *Cupressus benthamii* (E.P.20) of annual pruning to one-half tree height, two-thirds tree height and three-quarters tree height up to 30 ft. were continued. After three years the retarding effect was, in terms of volume, some 30 to 50 per cent in the *P. radiata* and 10 to 40 per cent in the cypress depending on the intensity of the pruning. This year there has been a general fall-off in both height and diameter increment, due, most probably, to the increased root competition

combined with a poor climatic year. The interesting observation was that in the cypress there appeared to be a small stimulation in height growth in the two more drastic pruning treatments.

E. Species Trials (Mainly Exotics)

Arboretum

Eleven new plots were planted (1961). Five are new species (*Callitris, Prosopis, Acacia, Platanus* and *Arundinaria*); two are different seed origins of these new species (*Prosopis* and *Platanus*); the other four are different seed origins of existing introductions. Two plots, *Nothofagus obliqua* and *N. procera,* were abandoned this year, neither species were suited to our conditions.

We now have 229 plots of 168 species of which 51 are eucalypts (76 plots), 24 pines (39 plots), 15 cypresses (18 plots), 11 acacias (16 plots), 6 *Callitris* (11 plots) and 61 other species (69 plots).

Next year we shall be introducing some 20 pine species from Central America.

The 16 species listed in the 1959 report and the eight species listed in last year's report have continued to grow well with the exceptions of *Eucalyptus regnans,* which has suffered considerably from the three years of low rainfall, and *E. globulus* and *E. bicostata,* which have both been under continuous and heavy attack from the eucalypt weevil (*Gonipterus scutellatus*).

Four new species are showing promise: —

Eucalyptus nitens
23 ft. in two years.

Eucalyptus goniocalyx
24 ft. in two years.

Eucalyptus rubida
20 ft. in two years.

Casuarina stricta
17 ft. in two years.

Generally speaking, all the very many different species in the Arboretum have stood up remarkably well to the last three years of marginal rainfall. Out of the 168 species only one (*Hagenia abyssinica*) has succumbed to the drought, which is not surprising considering that it is well below its normal altitude range. A number of specimen trees were also lost, but only the younger plants where they were in competition with grass.

Live Hedges

The extension plantings done in 1960, in which all existing hedges were replicated, have all grown well. The object is to find out the most suitable and cheapest management technique to achieve an efficient hedge for each species applicable in large-scale farming.

The five species, *Solanum* sp., *Caesalpinia seperia, Buddleia* sp., *Dodonaea viscosa* and *Cupressus lusitanica,* have grown very rapidly indeed and have been cut back once or twice already to keep them to a manageable size.

In the older, original hedges trial the hedge of *Dodonaea viscosa* has died out completely owing to the drought.

International Eucalyptus Trial (I.U.F.R.O.)

The experiment is now nearly five years old. Of the 12 species or strains tried only three are likely to be of any use in East Africa, and these we have had already for many years. They are *E. botryoides* of Victoria (Aust.) origin and *E. saligna* of two origins (N.S.W. Aust., and Kenya). Two origins failed to germinate (*E. nitens* and *S. saligna* (Uganda origin)) and six were badly and continuously attacked by the eucalyptus weevil (*Gonipterus scutellatus*) as soon as the juvenile foliage changed to adult foliage (*E. camaldulensis* two strains, *E. viminalis* three strains, and *E. bicostata*). All three origins of *E. viminalis* suffered severely during the drought of three successive years.

In November, 1961, we gave the plots of trees their first thinning, taking out roughly 40 to 50 per cent of the stems. The better species or strains now have the following dimensions (after thinning): —

Species	Top ht.	Mean B.H.D.	Basal area per acre	No. stems per acre
	ft.	*in.*	*sq. ft.*	
E. botryoides (Victoria origin)	44	4·9	38·38	288
E. saligna (N.S.W. origin) ..	43	4·5	36·69	326
E. saligna (Kenya origin) ..	43	4·6	35·93	310

IV. ENUMERATIONS AND V. REGENERATION OF HARDWOODS

Work continues in these subjects. E.A.A.F.R.O.'s contribution was purely advisory.

VI. SHORT-TERM TREE CROPPING

The replicated ten-acre experiment to compare the relative fuel yields of three eucalypts (E.P.14) is now in its second rotation. Coppice regeneration is up to a height of 20 ft. and the number of stems per stool will be reduced next year. The next clear felling and measurement of yields will occur in 1965.

The experiment (E.P.18), started in 1958 to test the effect of different methods of felling on stool mortality in *Euc. saligna,* was remeasured during the year. Twenty-seven months after felling the axe-felling mortality was 6 per cent and the saw-felling was 2 per cent.

An experiment (E.P.25) to test the effect of the fuel and pole yield of reducing two-year-old *E. saligna* coppice regeneration to varying numbers of stems per stool was maintained during the year. Measurement and assessment will be done at age five years.

The three new studies (E.P.s 22, 23 and 24) started last year in the Arboretum plot of six-year-old bamboo (*Oxytenanthera abyssinica*) were continued this year.

E.P.22.—This experiment is designed to find out the annual yield of culms by weight (i.e. tons per acre). The yield this year was approximately ten tons per acre green weight or five tons after three months' drying, from a 60 per cent thinning of the oldest culms.

E.P.23.—We have no indications yet as to the length of life of individual culms.

E.P.24.—This year's experiment is our second set of observations to find out the rate of growth of new culms. Our present indications are that rate of upward growth is rapid and smooth, the new culms take some eight weeks to reach their maximum height of approximately 15 ft. and side branches and foliage are produced after five weeks.

VII. YIELD TABLES FOR IMPORTANT SPECIES

The first provisional yield tables for the cypresses of the *C. lusitanica* group have been completed during the year. The tables are on an East African basis and will be issued in *E.A.A.F.R.O. For. Tech.* Note No. 11 early in 1962.

VIII. MUGUGA (E.A.A.F.R.O.) ESTATE

Routine management continued during the year.

A working plan is being compiled.

Petty thefts have been a continued source of nuisance during the year but there has been a marked improvement since the establishment of two forest guard posts.

Three fires occurred during the dry season (January, February and March) but all were extinguished before any real damage had been done.

FOREST ENTOMOLOGY

Tecwyn Jones and W. Wilkinson

The junior staff complement of this Division was greatly increased during the past year. As a result of this, progress in the three major fields of work has been more continuous and far less spasmodic than in the past. Borer research and termite investigation teams have now been established and are reasonably well trained in their specific functions. The Insect Survey Unit is still below strength but with the appointment of a fully trained Research Assistant in the near future, it is hoped that this unit will attain greater efficiency in insect determinations and hence be able to cope with the ever increasing and formidable task of compiling and maintaining our Forest Insect Reference Collection.

EAST AFRICAN FOREST INSECT SURVEY

The source of insect collection has inevitably extended as a result of a wider sphere of activity of our own staff, but in addition to this, a much more comprehensive survey has been established in Tanganyika. There, each major forest station has been issued with collecting equipment and Forest Officers are responsible for making regular collections in their area. This has not only increased the geographical range of the survey but has also released the two Insect Rangers from routine collecting and permitted them to undertake more specific investigations such as a survey of the Kilimanjaro and Rufigi forests.

A duplicate reference collection of more than 1,000 specimens has been installed at the Silviculture headquarters at Lushoto.

THE BORERS OF ESTABLISHED FORESTS AND PLANTATIONS

Tecwyn Jones

Investigations have necessitated a number of safaris to the West Usumbaras, Eastern and Western Provinces of Tanganyika, the Western Province of Uganda and the Highland forest areas of Kenya.

(1) *Borer of* Isoberlinia scheffleri *in Tanga Province*

This pest, which makes large holes in living *Isoberlinia* has been determined by the United Kingdom specialist as an undescribed species of *Prosopocera* of the family Lamiidae. Adults, pupae and numerous larva have been obtained by breeding and collection

and have been submitted to the British Museum for description. The species is considered to be of particular interest on account of its unsually large size for the genus *Prosopocera*.

The studies of this borer have been directed mainly toward the elucidation of its biology and a census of its depredations in the Kwakoro/Amani Forests. It has now been clearly established that the adult oviposits in or below the bark of living trees and the hatching larvae burrow, not in the dead or heartwood (as was previously concluded from studies of sawn logs and timber) but within the saturated sapwood. This habit is reflected in a somewhat unusual life history and also provides certain highly realiable features which indicate the presence of the borer in the tree. On the basis of these features it has been possible to survey accurately the degree and incidence of borer attack in limited areas. Results have shown that infestation first occurs in living trees when they are of one to two foot girth and may continue at intervals throughout the life of the tree. Trees are attacked anywhere from ground level to the lower part of the crown. In certain areas of the Kwamkoro Forest 87 per cent of commercial size trees (i.e. over 8-ft. girth) are infested, but this figure drops to 50 per cent in adjacent areas.

(2) *Borer of* Syzygium quiniensee *in Tanga Province and Western Western Province, Uganda*

This is a subsidiary project to (1) above. The insect responsible is a member of the Callichromini, the larva of which bores in living sapwood. Infestation seems to be confined to buttresses and the bole up to and never beyond the lower forest canopy, i.e. about 40 ft. The incidence of attack can be particularly heavy often reaching 90-100 per cent in localized areas.

(3) *Borer of* Parinari excelsa var holstii *in Western Uganda*

This Lamiid which has been the subject of various investigations in Uganda since 1950 has been obtained in larval and pupal forms and one adult has been reared. It is an undescribed genus and species near the Phrynetini (probably Xylorhizini).

The biology of this borer is complicated in the larval stage particularly. Oviposition occurs anywhere from just at or below soil level on the buttresses and the larvae frequently bore downwards into the roots before finally meandering up the bole to pupate. All galleries are confined to sapwood and have characteristic grass-ejection holes at intervals along their length. The last stage larva excavates the exit hole prior to pupating.

Trees of but a few inches girth are attacked and infestation continues throughout the life of the host. In the Kalinzu forest borer incidence is particularly heavy and in the area now being exploited 98 stumps of Parinari out of the 100 examined were infested.

(4) *Borer of* Brachystegia spiciformis *in Western Province, Tanganyika*

This tree, which is closely related to *Isoberlinia* commonly exhibits large borer tunnels when crosscut or converted. To date one unidentified borer has been found actively attacking living trees in Tabora. Its biology is dissimilar to that of *Prosopocera, Syzygium* and *Parinari* borer as it bores downwards from small branches to the main trunk—a length of more than 20 ft. in the case examined. It is not known as yet whether this species alone is responsible for damage to *Brachystegia*; another (*Prosopoceran*) may be involved.

Bark Beetles

An instance of ten-year-old Cypress trees dying off at Cengalo was investigated at the request of the Assistant Forest Entomologist, Kenya. It was found that the trees in question were heavily infested by the Scolytid *Phloeosinus schumensis* and that this insect with its galleries was virtually ring-girdling branches. It seems that this attack on living trees by an insect which is normally confined to infesting sickly or dying trees was only possible because of the severe drought conditions which prevailed at that time. The trees were severely weakened before being attacked, but had they not been attacked by *Phloeosinus* they would in all probability have fully recovered with the onset of the rains.

Assessment of Oemida Incidence in Plantation

This has barely started but a small pilot trial to assess the incidence of this borer and others e.g. weevils in game-damage cupressus was carried out in the Nyeri area of Mount Kenya. Twenty-five trees, taken as a systematic sample were felled in each of six plantations and crosscut at 5-ft. intervals from the butt to the region of 9-in. girth. The crosscut surfaces were examined in detail for evidence of infestation and the results compared with those obtained by core-drill samples. Results are not yet fully analysed.

TERMITES AND AFFORESTATION

W. Wilkinson

Two of the field trials on the protection of young plantations against termite attack have unfortunately been all but terminated by severe drought. Useful information has been obtained, however, on apportioning the blame against termites, and on their methods of attack. No instance has yet been seen of a treated tree being killed by termites, and convincing support is given to trials in other countries, showing that if insecticide is properly applied to the roots of a young tree in the nursery, or well distributed in the planting hole, practical protection is effected. The loss of the plots designed to find the minimum economic dose was unfortunate, but even the dead and dying trees treated with as little as 0.00625 oz. of Aldrin (active ingredient) showed no attack in six months. In areas where deep planting is necessary the newly buried part of the stem is very vulnerable. A method of sheathing the stem in the nursery with a narrow polythene tube filled with Aldrin treated soil was devised. Early death made the results inconclusive, but from the practical planting aspect the method was found too unwieldy for normal forest practice, and the resulting potting stock too heavy.

A new trial has just been laid out near Machakos in which the merits of plain Aldrin dips are being assessed in relation to deep and "flush" planting.

ADVISORY WORK

An interesting case of insect infestation in timber yards was investigated by Mr. Jones at the request of the East African Railways and Harbours. Mvule logs (*Chlorophora excelsa*) railed from Handeni in Tanganyika were heavily infested with Lymexylonidae (*Atracocerus* spp.) These on emerging in the Nairobi timber yard were infesting other clean mvule logs in the same yard and causing deep and extensive damage. This cross infestation was successfully checked by rapid conversion of all logs in stock.

Mr. Wilkinson at the request of the Kenya Forest Department contributed a section on termites to the Forest Ranger Handbook being prepared by J. Welford.

HORTICULTURE

W. B. May

Forestry Work

Several thousand *Eucalyptus saligna* pines, and cypress were raised for estate planting.

The Horticulturist continued to do advisory work on nursery techniques and the growing of plants generally for the East African Departments of Forestry. The three territories have received selected vegetative material of *Pinus radiata* originally imported from Australia. The grafting of this material has been carried out by the Horticulturist in the territories.

Horticultural Work

The Horticulturist was on long vacation leave from January to August, 1961, and in November took over E.A.P.Q.S. in the absence of Mr. Dickinson on vacation leave. Consequently little time has been available for horticultural experiments.

Floral decorations for the East Africa High Commission stand at the Nairobi Royal Agricultural Society's Show and High Commission Headquarters building, Nairobi, were provided by the Horticulturist.

EAST AFRICAN HERBARIUM

B. Verdcourt, G. L. Lucas, D. M. Napper, R. Polhill and G. R. Williams

In the period 1st December, 1960, to 25th December, 1961, 350 accessions of material were received, totalling 10,922 specimens for determination, 3,202 named duplicates and 130 specimens received on loan for study (the figures for December, 1960, were not included in last year's totals). Routine naming of collections and the supplying of information has engaged nearly all of the staff's time. Some idea of the correspondence dealt with during the year can be obtained from the fact that about 1,600 communications are entered in the Herbarium post book for 1961. Few so-called research departments deal with such a volume of work. Eleven thousand eight hundred and eighty-six specimens have been determined during the year and 9,127 specimens have been sent to other institutions, including named duplicates and specimens sent on loan for study.

One of the largest collections dealt with during the year consisted of some 2,000 specimens collected by Dr. P. E. Glover and his co-workers during a survey of the Mau-Mara area. The Herbarium has also undertaken to prepare check lists and typed field notes. It is hoped that the considerable work of drafting, checking and final typing of these will be finished next year.

Mr. Lucas completed the laying away of the outstanding, named, mounted sheets mentioned in last year's report. During the course of this work he rearranged the ferns according to a more up-to-date system. A further 7,431 sheets await laying away. These are all numbered and sorted into families so that any person working on a family can see even the most recently acquired material. The total number of sheets in the Herbarium is now about 165,000 and it is certainly the largest and most important collection in tropical Africa. Since Dr. Verdcourt will be on leave during part of 1962, and Mr. Lucas will have to take over administrative duties, it is unlikely that laying away will be completed unless the services of a trained botanist can be obtained on a part-time basis.

A recount of the number of recorded types has been made since it was not certain what class of types Dr. Greenway had included in his counts. The resulting number is 1,329. This includes all classes of types and does not correspond to the number of valid names they represent. If, for example, the Herbarium holds five isosyntypes of one published name then these are counted as five

types. When, however, the Herbarium possesses several sheets of the same type gathering e.g. holotype and two isotypes these have been treated as one sheet.

Research work has been restricted owing to the volume of routine work. The book on Uganda grasses (an Illustrated Guide to the Grasses of Uganda) by Mr. K. W. Harker and Miss D. M. Napper, mentioned in last year's report appeared in print. Since her return from leave, she has devoted as much time as possible to completing a check list with keys of the grasses of Tanganyika. This involves dealing with the large number of 650-700 species and will be of the utmost value to agricultural and other workers, since the part of the Flora of Tropical East Africa dealing with grasses will not appear for many years. Miss Napper's work will be of considerable assistance to whoever takes on the long-term task of preparing that account. During the course of her leave, Miss Napper spent six weeks at Kew consulting type specimens and literature not available in Africa. A considerable number of new species, and some new genera, are involved.

Mr. Lucas has been so concerned with routine work, that he has spent no time at all on the families he is elaborating for the Flora. Dr. Verdcourt has had equally little time for research work. None of the six accounts prepared for the Flora has appeared in print during the year. One further small account, that of the Salvadoraceae, has been written and will be completed at Kew next year. Several small revisions were also started during the year and will likewise be completed at Kew, where proper bibliographic facilities are available. Several small revisions were published during the year. Dr. Verdcourt commenced a book on East African poisonous plants in conjunction with Mr. E. Trump of the Veterinary Department. The draft manuscript was completed and about a dozen of the plates required have been drawn by Mrs. Church. A great deal of work will be needed to prepare it for publication.

Mr. Polhill continued his studies on the genus *Solanum* and prepared an interim report which will be most valuable in assisting with the routine naming of this difficult group. He also prepared a short article on the ephemeral flowering Liliaceae of Kenya, illustrated mostly from living plants collected in the Machakos, Kinangop and Elgon areas. Accounts of the families Berberidaceae and Ulmaceae for the Flora were started and will be completed when Mr. Polhill takes up his duties at Kew.

The manuscript of a dictionary of plant names of the Washambaa, Wabondei and Wazigua peoples was completed by Mr. George Williams in 1960 and efforts have been made to find a

publisher, so far with no success. It seems likely that a mimeographed edition prepared at Muguga will have to suffice. The dictionary represents the results of over ten years' work.

There have been many visitors to the Herbarium during the course of the year, several of whom have made full use of the collections. Dr. Greenway has continued to work on his Serengeti survey collections and lists of medicinal plants. It is a pleasure to provide facilities to the person who built up the Herbarium to its present standing.

One of the highlights of the year was the long-awaited publication of *Kenya Trees and Shrubs* by I. R. Dale and P. J. Greenway. A considerable amount of the revisional work for this book was carried out in the East African Herbarium by Dr. Greenway. Its appearance will save the Herbarium staff a great deal of time. It is an accurate and invaluable work which should be in the hands of everyone dealing with the flora of East Africa. Another interesting work based on the Herbarium collections is an account by Gerloff, in *Willdenowia, 2,* (4), of some seaweeds from the Kenya coast. Mr. P. R. O. Bally's monograph of the genus *Monadenium* also appeared during the year. This is one of the most splendidly illustrated botanical works of this decade and much of the material it is based on is preserved in the East African Herbarium.

Considerable assistance was given to the Coryndon Museum with the rearrangement of the botanical paintings on show in the Botany Hall. The paintings were renamed correctly and Mr. Lucas spent several weeks labelling them and arranging them in order so as to convey as much useful information to the public as possible. Dr. Verdcourt co-operated with Mr. Ellis in a scheme to label the more conspicuous roadside trees and shrubs in the Nairobi National Park. At present only a few trees have been labelled but it is hoped to extend the scheme next year.

Owing to their many preoccupations in the Herbarium itself very little collecting has been undertaken by members of the staff, and it is one of their chief disappointments. In 12 years Dr. Verdcourt has collected only some 3,200 specimens and those mostly out of office hours. This number is equivalent to only about five months' work by a normal botanical expedition. Kew also are disappointed that more collecting is not carried out by the Herbarium staff. During 1961, Dr. Verdcourt collected at Namanga, Kajiado, Amboseli, Aberdares, Nairobi (mainly in connexion with a survey of the Game Park), Muguga, various places in Tanganyika whilst on reconnaissance for the East African Safari, Naivasha, Thika Gorge, various places on the Mombasa road, and

at Kitale. Mr. Lucas collected in the Garissa area and also at Kapenguria and in Kakamega Forest where he discovered a species of *Beileschiedia,* a genus not previously recorded from Kenya. He has not yet had an opportunity to name his collections. Assistance has been given to various collectors; Mr. Samwell Paulo was loaned first to Dr. Glover and then to Mr. Polhill, and Mr. Kanure Kibui assisted Dr. Greenway during part of his survey of the Serengeti.

Zoological Addendum

In zoological addenda to several previous Annual Reports it was mentioned that Dr. Verdcourt was making special collections of *Meligethes* beetles for Dr. A. M. Easton. Dr. Easton's studies on these have now appeared and no fewer than 17 new species have been described from the material sent by Dr. Verdcourt.

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY

L. D. Verdcourt, F. M. Searle, J. H. P. Storey, D. W. Lazarus and E. Kungu

The work in the library has unfortunately been hampered during the year by lack of staff. Mrs. Searle left in April for United Kingdom leave and no help was available until August when Miss Trapnell gave part time assistance for two months. Miss Storey started work in November and will continue throughout 1962 during the Librarian's absence on United Kingdom leave.

Lack of continuity in staffing has resulted in many of the long-term jobs being left untouched, but the routine work has been kept well up to date. This ensures that the reader is kept well supplied with the new incoming material. Accessions of books and periodicals are stamped and indexed and displayed in the library and some are routed to interested readers. References which are not in the stock of the library are searched for first in East Africa and then through the *World List of Scientific Periodicals* in United Kingdom libraries. Microfilms, photostats or reprints are obtained to meet the reader's requests and placed at their disposal. Searches through the literature are made for references for research workers and abstracted accordingly. Requests for reprints of papers published by members of staff are received and dealt with daily. This routine work though most important in an efficient library service is naturally time-consuming. Much more of the Librarian's time should be spent on re-cataloguing, classifying and indexing, stock checking, etc., but with the present staff position this is not possible.

The bookbinding staff have continued to work hard and produce well-bound periodicals. Mr. Okakah returned from long leave and spent a valuable month at Makerere College Library in the Bookbinding and Printing Department, and as a consequence has been able to improve some of our methods. Binding for other libraries continues and the adopted system works quite smoothly.

A complete check of the numerous loans was undertaken twice during 1961 and brought to light some interesting facts. Over 100 books and bound periodicals are borrowed each month from the library by members of the staff. However, very few are lost as the readers are most conscientious in looking after their loans and searching for misplaced copies.

Mr. Sentamu, a trainee librarian from Uganda, arrived in August to study this library's methods for a month. This was a new venture and proved quite successful. During his stay he paid daily visits to other libraries in Nairobi in order to compare classification schemes and methods of indexing and arrangement.

Altogether 1961 has been a very busy year in the library and more use has been made of the service than in the past decade. This is most satisfactory and it is hoped to improve facilities and the stock during the next year.

EAST AFRICAN AGRICULTURE AND FORESTRY JOURNAL

Editor: *J. Glover*

Acting Editor (*May-December*, 1961): *H. F. Birch*

During 1961 the Journal received rather more than the usual number of scientific papers, about 90 per cent of which were from workers in East Africa. Altogether 51 papers were published. The policy of publishing only original work was largely maintained, but one or two articles of general interest were accepted. Most of the papers published dealt with agricultural problems in East Africa but in many instances the results were applicable to other countries. Six papers were published on fisheries research which were also of general as well as local interest. Forestry articles were not well represented as so few papers were received.

Distribution of the Journal was maintained, and each quarter 1,201 issues were sent to subscribers and agents in East Africa, the Commonwealth and foreign countries, as well as in exchange for other scientfiic journals.

During 1961 one or two issues of the Journal were enlarged to cope with the large number of papers received. It is not clear whether the increased number of papers received is a reflection of the increasing world-wide pressure on scientific journals, and therefore likely to continue, or whether it is a local and temporary occurrence due to the desire of scientific workers leaving East Africa to get their work published before leaving. Should the present rate of influx continue it is possible that some of the 1962 issues of the Journal will have to be enlarged to avoid too great a delay in publication and to clear some of the current backlog of articles.

It is evident from the range of subjects covered that the Journal is of great value to scientists in East Africa in getting their work known both here and abroad.

The Editorial Committee is grateful to Dr. Birch for acting as Editor during the absence of the Editor on overseas leave for much of the year.

EAST AFRICAN PLANT QUARANTINE STATION

F. M. L. Sheffield and P. J. Dickinson

During the first three months of the year the scientific supervision of the station was undertaken by H. H. Storey, and during November and December W. B. May supervised the horticultural work and H. Y. Kulkarni assisted in various ways. We are again indebted to certain specialists, notably I. A. S. Gibson and A. G. Whitehead, who have advised us on disease problems during the year.

In June the post of Horticultural Assistant fell vacant through the resignation of Peter Mwithiga. After considerable difficulty was experienced in finding a suitably qualified replacement, David Ngusa was appointed in September.

Plant Collection Held at E.A.A.F.R.O.

Sugar Cane

Some 75 varieties imported through Muguga quarantine and which have subsequently passed through open quarantine here and at Kawanda have now been planted in the collection. Also included are some 27 varieties kindly supplied by the Uganda Department of Agriculture. These include most of the varieties of commercial importance in East Africa and also a number that would probably be needed should a breeding programme be initiated. A further 14 varieties are still held in open quarantine.

Other Plant Species

It is our intention to hold here also small quantities of any new varieties of other species that are imported by Governments and that will survive at this altitude. At present we hold only the sweet potato variety "Early Port" and a Pelargonium of high oil content.

Species Imported or Held in Quarantine During 1961

Cacao var. "Lafi 7"

These importations were initiated by the Uganda Department of Agriculture, but if and when material is released cuttings will be offered to all the other East African territories.

1. A consignment of rooted cuttings was received towards the end of 1960 in such poor condition that only one plant survived. As the root system of this appeared unhealthy and to be preventing growth of the shoot, approach grafts were made to two healthy

seedlings to produce two vigorously growing plants. If tests now being made to healthy "Amelonado" seedlings for the presence of virus prove negative, cuttings from the stock plants will be rooted for release.

2. A consignment of budwood was received and buds were successfully established on 16 healthy seedlings, but they have not yet been tested for the presence of virus.

Coffee

Only cuttings from the originally imported plants are sent out from quarantine. As all three mainland territories are usually interested in coffee importations, it is necessary to retain the plants for a considerable time after we are satisfied that they are healthy, to obtain sufficient material for distribution. Most of the plants in the three importations now held have been released but will be retained for some time yet for propagation.

1. *Coffea excelsa* var. 490/51.—Cuttings have been supplied only to Jacaranda Coffee Research Station.

2. *Coffea robusta.*—Some eight selections and hybrids were received in 1960. One was destroyed; cuttings from three others have been distributed to the Coffee Research Stations in all territories. Four of the selections are still retained for propagation.

3. *Coffea arabica.*—Rooted cuttings of some eight clones selected for rust resistance were received from Portugal in July. All plants are apparently healthy but so far only sufficient material has become available to supply a few cuttings to Jacaranda Coffee Research Station.

Dahlia varieties

Of a consignment of 25 tubers, each of a different variety, three were found to be virus infected. The remaining 22 gave negative responses to a series of six tests at monthly intervals for the presence of virus and were released to their importers, Messrs. Graham Bell Ltd.

Liquorice (Clycyrrhiza glabra)

Although no pathogen was found in a consignment received from Cyprus in 1960 on behalf of the Kenya Department of Agriculture, we were unable to obtain good growth and the plants were destroyed. As this species seems never to have been grown in Kenya, it was agreed that experiments should be done in the growing of varieties that can be imported on certificate only before special varieties that need to be quarantined are brought in.

Millet var. " Hedgehog Bulrush"

The Nyasaland Department of Agriculture sent some seed of this variety to the Kenya Department of Agriculture but stated that the parent crop had become infected with a fungus disease, suspected of being seed-borne. Six plants grown to maturity in quarantine remained healthy and ½ lb. of seed harvested from them was sent to the Plant Breeder at the Katumani Experimental Station, Machakos.

Pineapples vars. Australian Ripley Queen and U.C. Selected Queen

One dozen suckers of each variety were received in exceedingly poor condition due to delay in transit. Both varieties have now been established but a considerable time must elapse before we are able to complete the necessary tests especially for the presence of Tomato spotted wilt virus.

Pinus spp.

1. *Pinus insularis.*—Owing to heating in transit most of a consignment of scion material was rotten when received. It was also infected with a fungus identified by C.M.I. as *Lophodermium pinastri*. Only two scions from one clone were established on healthy stocks. These grew well for a time but when about 9 in.-12 in. long they were found to be infected with a fungus identified by C.M.I. as *Diplodiella crustacea*. Neither of the pathogens found on this importation has ever been recorded in East Africa.

2. *Pinus radiata.*—Scion material of 15 A.C.T. selected elite trees was received from Australia and 13 clones have been successfully established on healthy stocks in the quarantine houses. When passed as healthy, they will be released to the Horticulturist, E.A.A.F.R.O., for propagation and distribution.

3. *Pinus radiata.*—A further consignment of 20 clones was sent from Australia, but owing to delay and heating in transit none survived the journey.

Sansevieria—or Bowstring Hemp

Plants of four species and two hybrids were received unexpectedly from U.S.D.A. by the Kenya Department of Agriculture. Such plants should be imported as leaf cuttings when there is little danger of their carrying disease but these consisted largely of roots that might be infested with nematodes. They are therefore being grown in quarantine until a sufficient number of leat cuttings become available for release.

Sugar Cane

We have redoubled the precautions taken in the handling of this species. Early in 1960 a disease suddenly appeared and in a few days spread through some 11 varieties of a single consignment from U.S.D.A. contained in one pair of glasshouses. The appearance of the symptoms and the presence of bacteria suggested the disease to be Mottled stripe caused by *Pseudomonas rubrisubalbicans*. All the plants in the two houses were destroyed. Early in 1961 similar symptoms were seen on a single variety of a consignment of six from Wageningen, Holland. The stool was immediately destroyed and there has been no spread in this house. Very shortly after, similar symptoms were seen on a single stool of a variety from Coimbatore. Because of contact with virus infected plants the release of this variety had already been delayed: the stool that became infected was grown from a sett heat-treated after being taken from the plant grown from the originally imported sett. Bacteria were isolated from the lesions and found by the C.M.I. to be distinct from *P. rubrisubalbicans* and similar to, but not identical with, *P. rubrilineans*. We were also informed that the disease had been recorded only once previously and then in glasshouse conditions. It seemed most unlikely that we had imported the same rare organism three times in rapid succession from three different sources. It was more likely either that we were carrying it from house to house on clothing, etc., or that it was entering the houses from some alternative local host. So that the houses need seldom to be opened, the water supply system has been modified and all watering can now be controlled externally. When it is necessary to enter, officers wear fresh protective clothing for each house and this is plunged into disinfectant immediately upon leaving the house.

Until we were sure that the situation was under control, we refrained from importing any further varieties of cane. There has been no recurrence of the disease since March, 1961, and we hope soon to resume importations. In view of the threat to the industry, caused by the introduction of Smut disease, importations should in the future be restricted to varieties resistant to this disease and, as far as possible, resistant also to Mosaic.

The following varieties have been released from closed to open quarantine during 1961:—

B. 4744,
B.O. 10, 11,
Co. 440, 680, 684,
M. 134/32,
P.R. 809,
Ragner,

but owing to difficulties encountered in heat-treatment, the last three have not yet been distributed.

It was found necessary to destroy only one variety, P.O.J. 2722.

The following varieties were imported during 1961 : —
H. 44/2364, 46/2404, 48/4605, 49/5.

The following varieties, imported during 1960, are also held : —
B. 52298,
H. 32/1063,
P.O.J. 2753, 2801, 2822, 3142, 3150,
P.R. 975, 980, 1007, 1013.

Sugar Cane—Sorghum Hybrids

Eleven hybrids imported in 1960 on behalf of the Plant Breeder, E.A.A.F.R.O., have been released from closed quarantine. After hot-water treatment setts were planted at the Scott Agricultural Laboratories where, through the courtesy of the Director of Agriculture, Kenya, they are being grown in open quarantine.

Species Exported

As well as the normal issues of sugar cane varieties from closed to open quarantine in the territories, a number of varieties have been sent abroad. Three went to Ghana and the same number to the Central African Federation, two to South Africa and one to Ruanda-Urundi.

Scion material of two elite trees of *Pinus radiata*, imported from Australia, was supplied to Southern Rhodesia.

We were also able to supply to Mauritius cuttings of the Petunia clone that we originally obtained from South Africa for use in testing for the presence of Tomato spotted wilt virus.

Plant Import Control

Both authors continued to be concerned with administrative work in connexion with Plant Import Control, reference to which is made on page 60.

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